

**RECONCILING SUSTAINABLE AND RESILIENT DESIGN IN CITIES:  
CROSS LAMINATED TIMBER AND THE FUTURE OF  
JAPANESE WOODEN BUILDINGS**

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This thesis is dedicated to my husband, family, and friends with love and gratitude for their ongoing support in my endeavors.

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In countries particularly susceptible to environmental disturbances like Japan, discourse has centered on resilient design: seeking building materials that withstand natural forces to protect populations while being the most up to date with international trends in technology and science. As a culture with a long history of wood use in buildings, the sudden surge in stone, concrete, masonry, and steel production and use in building applications following the Meiji Restoration of 1868 signaled a momentous shift in Japanese architectural practices and customs. While a preference for these “modern” materials generally continues today, the properties and characteristics of wood and wood-derived products are being reexamined in light of worldwide ecology movements and perspectives in sustainable design that had not existed prior to the mid-twentieth century.

Using the subject of material culture as a lens through which Japanese urban architectural history and political debates are brought into sharper relief, this thesis argues that manufactured engineered wood products like cross laminated timber (CLT) are a part of the larger ongoing discussion on how to solve urban problems and offer the ability to connect sustainable and resilient building design agendas in cities. In addition, if CLT and other wood-based materials are domestically grown and responsibly manufactured on a larger scale than exists presently in Japan, industrial productivity of wood from local forests will recover after long periods of stagnant development, a move heavily invested by the present Prime Minister Shinzo Abe and his administration.



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### List of Key Terms and Abbreviations

BCJ	Building Center of Japan
BRI	Building Research Institute, Japan.
CASBEE	Comprehensive Assessment System for Built Environment Efficiency, Japan.
CLT	Cross Laminated Timber
EWP	Engineered Wood Products
IBEC	Institute for Building Environment and Energy Conservation
JSBC	Japan Sustainable Building Consortium
LEED	Leadership in Energy and Environmental Design, United States Green Building Council
MAFF	Ministry of Agriculture, Forestry and Fisheries, Japan.
MLIT	Ministry of Land, Infrastructure, Transport and Tourism, Japan.

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### Note on Japanese to English Transliteration

In my acknowledgements, Japanese names are transliterated according to personal preference. Within the body text of this thesis, as is the conventional Japanese way of naming, I list the surname prior to the given name whenever the person in question is Japanese. The exceptions are those Japanese authors and architects who have works attributed to them with the given name preceding the surname, as is the English convention. Additionally, I have transliterated Japanese words according to the Modified Hepburn Romanization system. Terms that have been “borrowed” from Japanese and have conventionalized English spellings, such as Tokyo or Shinto, are written this way.

## INTRODUCTION

After the first steel-framed building was erected in 1864,<sup>1</sup> a desire to build tall, resilient structures in Japanese and other global metropolises sparked competition amongst governments, designers, and architects in modern nation-states to showcase spectacles of power and innovation through grandiose architectural feats. While imperial undertones are no longer one of the drivers of architecture in Japan and most other contexts, multi-story wood buildings can be a solution to population growth and other urban problems in ways that support safe, attractive living and working environments for peoples from diverse socio-economic backgrounds. These types of structures additionally offer a variety of benefits, addressing a range of environmental and economic concerns, in ways that conventional materials cannot.

In countries particularly susceptible to environmental disturbances like Japan, discourse has centered on resilient design: seeking building materials that withstand natural forces to protect populations while being the most up to date with international trends in technology and science. Around the time steel-framed tall buildings were conceived wood quickly fell out of favor for its inability to effectively resist fire, decay, insect infestation, earthquake tremors, water damage, and other naturally occurring forms of deterioration. As a culture with a long history of wood use in buildings, the sudden surge in stone, concrete, masonry, and steel production and use in building applications signaled a momentous shift in Japanese architectural practices and customs. The intricate wood procurement and maintenance strategies implemented under the Tokugawa *shogunate*<sup>2</sup> were abandoned in favor of factories and steel mills. Wood was

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<sup>1</sup> The Oriel Chambers building in Liverpool, Great Britain was the first office building constructed with a steel frame in 1864.

<sup>2</sup> Conrad D. Totman, *The Green Archipelago: Forestry in Pre-Industrial Japan*, (Berkeley: University of California Press, 1989), 83-115.

increasingly seen as an inferior and weaker material as members of the Meiji oligarchy invited Western instructors supporting this viewpoint to educate Japanese carpenters, designers, city planners, and future architects.<sup>3</sup> This same line of thinking was supported by a majority of government and military bureaucrats who oversaw accelerated efforts to industrialize, militarize, and promote unprecedented economic growth in all areas, including building construction, for the Empire of Japan.

Widespread production and mass consumption of stone, concrete, masonry, and steel had unforeseen consequences that critically impacted the biosphere and global human health. While a preference for these “modern” materials generally continues today, the properties and characteristics of wood and wood-derived products are being reexamined in light of worldwide ecology movements and perspectives in sustainable design that had not existed prior to the mid-twentieth century. The use and production of cross laminated timber (CLT) now appears poised for a major boom in Japanese wood structures, especially in public buildings. Products derived from wood like CLT are just a number of the many construction materials that have been used by Japanese designers and architects over time in a never-ending quest to discover the most durable materials against earthquake and other natural disaster damage in cities. As total population in urban settings is projected to hit sixty-six percent by 2050,<sup>4</sup> some scientific communities have estimated that creative applications of wood in urban centers will accommodate future demand for low-, mid-, and high-rise public and residential buildings.<sup>5</sup> Even global media sources,

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<sup>3</sup> Gregory K. Clancey, *Earthquake Nation: The Cultural Politics of Japanese Seismicity, 1868-1930*, (Berkeley: University of California Press, 2006), 11-62.

<sup>4</sup> “World’s Population Increasingly Urban with More Than Half Living in Urban Areas,” The United Nations Department of Economic and Social Affairs, last modified July 10, 2014, <http://www.un.org/en/development/desa/news/population/world-urbanization-prospects-2014.html>.

<sup>5</sup> Jan-Willem Van De Kuilen, Ario Ceccotti, Zhouyan Xia, Minjuan He, “Very Tall Wooden Buildings with Cross Laminated Timber,” *Procedia Engineering* 14 (2011): 1-8, accessed on April 1, 2015, doi:10.1016/j.proeng.2011.07.204.

including the New York Times,<sup>6</sup> the Guardian,<sup>7</sup> Globe and Mail,<sup>8</sup> and NHK<sup>9</sup> have featured articles that consider the potential for new multi-story wooden buildings in cities and towns.

An aim of this thesis is to add to the rich conversation of Japanese architecture that exists in the fields of urban and environmental history by offering a unique perspective in the area of material culture through the discussion of contemporary wood products and wood use. Conrad Totman in the seminal *The Green Archipelago* was one of the first Western scholars to research Japan's wood and forestry policies, principally within the timeframe of 1600-1870. Totman found that despite centuries of exploitation of natural forests by humans, programs of woodland protection and regenerative forestry were set in place by powerful *daimyō*. These *daimyō* foresaw that resources were depleting at a rate that was not sustainable for future populations and anticipated dire social, economic, and environmental consequences.<sup>10</sup> While wood remained the main material used for residential and non-residential applications at this time, the harvesting and manufacturing of wood was regulated and only select carpenters collectively known as *daiku* had the training and skills required for building.

Gregory Clancey in the immensely important *Earthquake Nation* extends the scope of Totman's work, revealing that from the Meiji Restoration (1868) to the Great Kantō earthquake

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<sup>6</sup> Henry Fountain, "Wood that Reaches New Heights," *The New York Times*, June 4, 2012, [http://www.nytimes.com/2012/06/05/science/lofty-ambitions-for-cross-laminated-timber-panels.html?\\_r=0](http://www.nytimes.com/2012/06/05/science/lofty-ambitions-for-cross-laminated-timber-panels.html?_r=0).

<sup>7</sup> Athlyn Cathcart-Keays, "Wooden skyscrapers could be the future of flat-pack cities around the world," *The Guardian*, October 3, 2014, <http://www.theguardian.com/cities/2014/oct/03/-sp-wooden-skyscrapers-future-world-plyscrapers>.

<sup>8</sup> Brent Jang, "Could high-rises be built of wood?," *The Globe and Mail*, June 18, 2013, <http://www.theglobeandmail.com/report-on-business/breakthrough/could-high-rises-be-built-of-wood/article12653588/>.

<sup>9</sup> "Susumu toshi no 'mokuzōka': ringyōsaisei he no chōsen," *Kore made no hōsō*, Nippon Hōsō Kyōkai (NHK), Tokyo, Japan: 3337, April 18, 2013, [http://www.nhk.or.jp/gendai/kiroku/detail02\\_3337\\_all.html](http://www.nhk.or.jp/gendai/kiroku/detail02_3337_all.html).

<sup>10</sup> Chapter 3 contextualizes timber depletion during 1570-1670 and Chapters 4, 5, and 6 outline forest regulation, silviculture practices, and forest plantation policies that were enacted by strong *daimyō* like the *shogun* and managed principally by the *bakufu* and *han*.

(1923) materials used in building construction experienced a shift from traditional wood to “modern” materials. This shift was based on a belief held by foreign architects and engineers that knowledge of Western science and findings in seismicity were superior to the experiences found in wood construction of Japanese *daiku* and other traditional craftsmen. Clancey illustrates the fallacy of this belief by highlighting the aftermath of the Nōbi earthquake (1891) where many buildings made from “modern” materials fell, while wooden structures demonstrated superior survivability. This incident greatly affected Japanese perceptions and relations thereafter with the West and with Japan’s own policies of self-fashioning into a modern nation-state.

Other important contributors to this topic include, but are not limited to: William Coaldrake in *Architecture and Authority in Japan* who connects the idea that buildings are tangible cultural vestiges, built by designers who have been influenced by the political motivations and religious beliefs of Japanese leaders throughout history;<sup>11</sup> André Sorensen in *The Making of Urban Japan* who highlights that the central government’s strong hand in Japanese urban affairs during the twentieth century emphasized economic expansion over issues like public welfare, health, or quality of life in cities.<sup>12</sup> Moreover, Carola Hein’s chapter in *The Resilient City* underscores that Japan’s elusive urban culture endures, changing only gradually while the nation’s cities and the buildings within are altered based on new technological innovations or destroyed from natural disasters and conflicts quite rapidly.<sup>13</sup> Dana Buntrock also offers insight in *Materials and Meaning in Contemporary Japanese Architecture* on the philosophies behind architects who select “traditional” materials, like wood, in their

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<sup>11</sup> William Coaldrake, *Architecture and Authority in Japan*, (New York, NY: Routledge, 1996).

<sup>12</sup> André Sorensen, *The Making of Urban Japan: Cities and Planning from Edo to the Twenty First Century*, (New York, NY: Routledge, 2004).

<sup>13</sup> Carola Hein, “Resilient Tokyo: Disaster and Transformation in the Japanese City,” in *The Resilient City: How Modern Cities Recover from Disaster*, ed. Lawrence J. Vale and Thomas J. Campanella, (New York, NY: Oxford University Press, 2005).



contemporary designs.<sup>14</sup> Lastly, Scott O'Bryan's chapter in *Environment and Society in the Japanese Islands* and related conference paper "Hot Infrastructures: Concrete, Climate Change, and the Built Environment of Post-World War II Tokyo"<sup>15</sup> call attention to the theme of material choices found in present-day buildings and infrastructure in cities, items that have directly impacted long-term climate change and have had other unanticipated environmental consequences.<sup>16</sup> Resources on wood in Japanese architecture and joinery techniques have provided a solid background on the culture of Japanese wooden buildings<sup>17</sup> while Andrew DeWitt's "Three Cheers for Abe's High-Tech CLT Wooden Arrow: The Future of Japanese Construction" was an invaluable launching point.<sup>18</sup>

Another purpose for this thesis is to educate readers on engineered wood products (EWPs) like CLT so that the opportunities and barriers to widespread use of these materials is understood. EWPs, such as CLT, differ from past material choices by having a higher potential for being eco-friendly and when paired with newly engineered design elements, can be used to significantly alter urban landscapes in positive ways. Sophisticated techniques in joinery and earthquake shock-absorbing pillars characterized Japanese wooden buildings from antiquity, but with new enabling technologies, society is in a position to design CLT and other wooden

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<sup>14</sup> Dana Buntrock, *Materials and Meaning in Contemporary Japanese Architecture: Tradition and Today*, (New York, NY: Routledge, 2010).

<sup>15</sup> Scott O'Bryan, "Hot Infrastructures: Concrete, Climate Change, and the Built Environment of Post-World War II Tokyo," [paper presented at the Annual Conference of the Association for Asian Studies, Philadelphia, PA, March 28, 2014].

<sup>16</sup> Scott O'Bryan, "The Temporalities of Urban Adaptation: Tokyo, Heat Islands, and the Climatic Dilemmas of Built Environments," in *Environment and Society in the Japanese Islands: From Prehistory to the Present*, ed. Bruce Loyd Batten and Philip C. Brown, (Corvallis: Oregon State University Press, 2015).

<sup>17</sup> Recommended sources include Christoph Henichsen, *Japan Culture of Wood: Buildings, Objects, Techniques*, (Basel, Switzerland: Birkhauser – Publishers for Architecture, 2004), Kiyoshi Seike, Yuriko Yobuko, and Rebecca M. Davis, *The Art of Japanese Joinery*, (New York, NY: J. Weatherhill, 1977), and Azby Brown, *The Genius of Japanese Carpentry: Secrets of an Ancient Craft*, (Tokyo, Japan: Tuttle Publishing, 2014).

<sup>18</sup> Andrew DeWitt, "Three Cheers for Abe's High-Tech CLT Wooden Arrow: The Future of Japanese Construction," *The Asia-Pacific Journal* 12, no. 2 (2014), <http://www.japanfocus.org/-Andrew-DeWitt/4162/article.html>.

products that are better equipped to resist fire and other natural disasters. Furthermore, CLT as an inherently wooden product has characteristics that support sustainable initiatives in line with recent regulatory responses by the Japanese government, such as carbon saving and low thermal emission properties. CLT and other EWPs have the capacity to bridge the gap between sustainability and resiliency, two important frameworks in architecture of the twenty-first century that have separate systems of measurement and are often evaluated by separate organizations. Moreover, the softwood needed for CLT manufacturing can be a key contributor to revitalize domestic wood production markets while providing adequate living and working spaces in future cities. Indeed, Japan is poised for what can be called a “wood renaissance.”

Using the subject of material culture as a lens through which Japanese urban architectural history and political debates are brought into sharper relief, this thesis argues that wood-derived products like CLT are a part of the larger ongoing discussion on how to solve urban problems and offer the ability to connect sustainable and resilient building design agendas in cities. In addition, if CLT and other wood-based materials are domestically grown and responsibly manufactured on a larger scale than presently exists in Japan, industrial productivity of wood from local forests will recover after long periods of stagnant development, a move heavily invested by the present Prime Minister Shinzo Abe and his administration. The first chapter, titled **Wood and the History of Materials**, situates this thesis into the context of Japanese urban architecture by detailing the rise of modern materials like concrete and steel and the fall and gradual recovery of wood products and Japanese forests. The second chapter, **Cross Laminated Timber, Sustainability, and Resilience**, brings CLT into the conversation by highlighting attributes of this product that contribute to sustainability and resilience design frameworks.

Chapter three, **Wood Buildings and the Future**, discusses contemporary Japanese wooden buildings and speculates on the future of Japanese wooden architecture in cities.

## **CHAPTER 1: WOOD AND THE HISTORY OF MATERIALS**

This chapter aims to establish background knowledge of material culture in Japan. It begins with a discussion on debates over changing views of building materials in Japanese urban architecture following the Meiji Restoration of 1868. It then continues on to contextualize the status of Japanese forests and wood procurement policies beginning in post-war Japan.

### ***1.1 Materials for Modernity: Stone, Concrete, Masonry, and Steel***

Until the late nineteenth century, most Japanese buildings were made primarily of wood. There are at least four factors that explain why a cultural preference for wood endured throughout most of Japan's history. The first, and most straightforward reason, is the fact that Japan naturally has an abundance of wood, bamboo, reeds, straws, and other types of grasses. Since hunters-and-gathers first began settling on the archipelago of Japan, they have been faced with the unique challenge of designing structures on small, mountainous islands, endowed with lush forestry but with limited land-use potential. Since Japan is about sixty-seven percent forested, carpenter and craftsmen techniques like joinery have evolved to make use of a variety of wood types with varying degrees of elasticity and hardness.

A second factor that explains a preference for wood is found in topographic reasons, including factors related to climate and natural disasters. To an extent, most regions of Japan experience meteorological differences during the four seasons, but temperatures vary depending on location with northern territories like Hokkaido being much cooler year-round than the southern Okinawan Islands. Depending on the design, wood can function as an insulator in the

cold or be breathable in summer months because air pockets in the cellular structure allow for heat to be contained or easily released in warmer weather.<sup>19</sup> Additionally, despite temperature differences, one common feature in all regions of Japan is relatively high humidity levels due to the country being surrounded by water. Some wood types native to Japan inherently absorb and expel moisture from humidity, a feature that has contributed to the widespread use of *hinoki* (Japanese cypress) and *sugi* (Japanese cedar) in vernacular forms.<sup>20</sup> Another key aspect that has influenced architectural design is the threat of natural disasters like earthquakes, tsunamis, or volcanic eruptions. Though not conventionally thought of as an ideal material in disaster scenarios in the present-day, the construction and design arrangements of wood by Japanese craftsmen was remarkably aseismic, flexible, and durable for the time.<sup>21</sup>

The third and fourth explanations are slightly more complex. The manner in which material practices and technology have been received in Japan is the third reason why wood has been the primary medium used in construction projects. In the sixth-century, the Korean state of Paekche introduced Buddhism, originally from India, and wooden temple construction techniques based on Chinese approaches to design, many of which were more sophisticated than the typical pit-dwellings that characterized the Jōmon and Yayoi period cultures of Japan.<sup>22</sup> However, while it is known from archaeological evidence that many Japanese pre-Buddhist buildings were built from wood, the new technology from China and Korea was “quickly canonized as emblematic of the new political regime, which sponsored its development and the

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<sup>19</sup> Carl Hagstrom, “Understanding Moisture Content and Wood Movement,” *This is Carpentry* (blog), Katz, September 30, 2014, <http://www.thisiscarpentry.com/2010/09/03/moisture-content-wood-movement/>.

<sup>20</sup> Ralph Manning and Virginie Kremp, *A Reader in Preservation and Conservation*, (Munich, Germany: Saur, 2000), 123.

<sup>21</sup> Clancey, 78.

<sup>22</sup> Kazuya Inaba and Shigenobu Nakayama, *Japanese Homes and Lifestyles: An Illustrated Journey Through History*, trans. John Bester, (Tokyo, Japan: Kodansha International, 2000), 16-21.

education of new generations of craftsmen.”<sup>23</sup> Aristocrats in the Yamato court took aspects of these Chinese and Korean influences they found to be most appealing and ordered structures such as temples and homes to be built based on these aesthetics after centralizing the construction industry into an official organization. To prepare carpenters and craftsmen for work demands, Korean specialists were invited to teach students and apprentices the new techniques in advanced joinery.<sup>24</sup> The bureaucratic and educational systems at this time in Japan tended to adapt wood-working technologies from Korea and China but resisted the use of advanced masonry techniques. Such factors as price and the susceptibility of stone and brick techniques at the time to earthquake damage likely affected the decisions made by those in power, while one motivation that had particularly strong authoritative influence on architecture was Japan’s indigenous religion – Shinto.<sup>25</sup>

Shinto, and its fusion with Buddhism, is the final reason that helps explain why wood has been a common material used in Japanese architecture. Shinto is a belief system based on the veneration of objects found in nature, as many were, or are, thought to be gods themselves. Proper care and treatment of organic elements, like wood, was, and in some cases still is, required in order to appease and avoid punishment by deities. Today there are less people who believe in the spirituality of nature, but many Shinto ideals remain deeply-rooted in Japanese cultural practices and customs. In a similar way, the basic Buddhist ideals that entered Japan back in the sixth century have also continued to influence cultural traditions, such as the senses of impermanence and simplicity. Wood is impermanent once it is cut down to be used in architecture and is valued for its natural simplicity. This combination of Buddhism and Shinto

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<sup>23</sup> Brown, 20-21.

<sup>24</sup> David Young and Michiko Young, *The Art of Japanese Architecture*, (Tokyo, Japan: Tuttle Publishing, 2007), 38-39.

<sup>25</sup> Coaldrake, 16-18.

principles has characterized much of Japan's history as both religions advocate respect, humility, care, and compassion to the natural world.<sup>26</sup>

Even before the Meiji Restoration of 1868, as new weapons like the canon, the arquebus, and other forms of artillery became accessible in Japan from foreign countries, *daimyō*, samurai, and other elite members of society started to instruct the *daiku* artisan class of carpenters and craftsmen to integrate other materials, such as stone, into their great fortresses and castles for added protection. The interior and exterior design elements of these castles, like the foundation, walls, and other partitions, however, largely remained wooden because the adaptability of wood design was more resilient against Japanese earthquakes than stone, which has little to no elasticity (*See Figure 1*).<sup>27</sup> While this signaled the start of the transition away from wooden buildings constructed using sophisticated carpentry techniques that had come to characterize the *daiku* artisan class in Japan to a style that employed stone and brick masonry based on Western methods, it was a slow shift entrenched in nationalistic and political debates.



**Figure 1:** The use of stone for fortification purposes paired with wood building design as seen in Odawara Castle in Odawara City, Kanagawa Prefecture, 1706.

*Source: Amy Klouse Fuentes, 2012*

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<sup>26</sup> Brown, 20-21.

<sup>27</sup> Stephen Turnbull, *Strongholds of the Samurai*, (Oxford, United Kingdom: Osprey Publishing, 2009), 138-150.

In many ways, the architectural discussions that took place at this time reflect the uncertainty many leaders had about the future of Japan in terms of geopolitical, social, and economic affairs and forced these decision-makers to choose whether or not Japan should take steps to industrialize and adapt certain construction materials and methods from countries. Two clear factions emerged regarding Japanese buildings: those in favor of fully adopting Western materials and styles and those who were in support of maintaining but improving Japanese design techniques based on new Western models. To educate *daiku* and other professionals on Western building design frameworks, the Japanese government invited instructors from other countries who taught that wood-framed structures were “deficient both in strength and stability,” and that wood was a more primitive medium than materials that marked civilized nations like stone or brick.<sup>28</sup> Moreover, wood was believed to be more “temporary” while materials like stone or brick were considered more “permanent” or more able to withstand weathering and damage from natural forces.<sup>29</sup> As a result, many Japanese designers and architects came to accept this standpoint and gradually moved away from using wood in public edifices.

Increasingly, Japanese builders and designers experimented with using more stone, brick, and later concrete. The architectural transformation of the Ginza district in Tokyo is an example that reveals Western materials in the Japanese landscape were initially ill-performing. After a major fire that destroyed a large part of Ginza in 1872, English engineer Thomas J. Waters was invited to rebuild the destroyed area with brick structures. The buildings were modeled after European styles that did not particular suit Japanese lifestyles and were not engineered to be sufficiently earthquake or fire-resistant as they were destroyed in 1923 during the Great Kantō

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<sup>28</sup> Clancey, 78, 84.

<sup>29</sup> Ibid., 12-15.



earthquake.<sup>30</sup> Moreover, during the Nōbi earthquake (1891), a majority of buildings in Osaka and Nagoya made of brick masonry were destroyed, fueling debates over whether or not imported “Western” materials were fragile and not applicable in future Japanese architecture projects.<sup>31</sup>

While many argued for refocused attention on identifying mediums in buildings that were “uniquely Japanese” as well as flexible yet resilient to seismic forces, others sought ways to improve the performance of these new Western materials. Japanese research on the surviving structures of an earthquake and fire in San Francisco (1906) combined with later studies on Tokyo’s own Great Kantō earthquake served as an impetus for change leading planners and designers to incorporate reinforced concrete (concrete encased in steel framing) and other steel-framed materials in Japanese buildings. The studies found that new applications of steel and the invention of reinforced concrete performed exceedingly well in buildings in these and similar disaster scenarios.<sup>32</sup>

In addition, modern city planning, such as land reform and building codes, were invented in Japan at this time<sup>33</sup> including the 1919 Urban Building Law that regulated building design and promoted concrete and steel use.<sup>34</sup> A new architectural style known as the Imperial Crown (*teikan yōshiki*) emerged in Japan, which rejected wood-based materials and viewed concrete as the most resilient and innovative material of the time.<sup>35</sup> This style, with its characteristic concrete infrastructure complemented with tiled roofs, heavily influenced Japanese architecture throughout the 1920s and 1930s, particularly in government and military structures such as

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<sup>30</sup> Hein, 217.

<sup>31</sup> Clancey, 180-211.

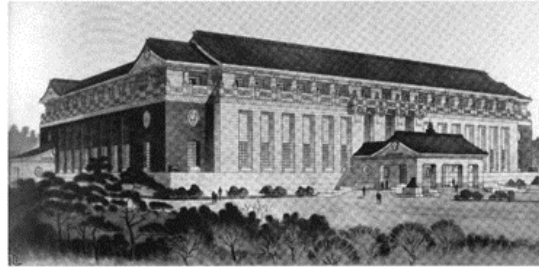
<sup>32</sup> O’Bryan, “Hot Infrastructures,” 4.

<sup>33</sup> Sorensen, *The Making of Urban Japan*, 114-118.

<sup>34</sup> Ibid, 151-200.

<sup>35</sup> O’Bryan, “Hot Infrastructures,” 4-5.

Watanabe Jin's Imperial Household Museum (present-day Tokyo National Museum, or *Tōkyō Kokuritsu Hakubutsukan*) as shown in Figure 2 and Ono Takeo and Kawamoto Ryuichi's Soldiers' Public Hall (*Gunjin Kaikan*).<sup>36</sup>



**Figure 2:** Competition entry by Watanabe Jin of the Tokyo Imperial Household Museum, 1931.

*Source: Jonathan M. Reynolds, 2001*

It merged features of “Western” design (concrete) with features of “Japanese” design (earthen tiles), shaping Western models of modernity to support Japanese nationalism. In the words of Arata Isozaki:

Beginning in the late 1920s, the Japanese nationalist “decorated shed” became popular as an easy, practical way of representing Japan-ness...Many thought that the *teikan* style was the most direct way of realizing that purpose, and accordingly a number of public buildings of the prewar era showed such ideology.<sup>37</sup>

As an emerging class of architect-engineers utilized this new construction medium to the fullest, new banks, department stores, and entertainment centers like movie houses and theaters speckled the landscape of city business and shopping districts. This spirit of concrete construction was short-lived, however, when state policy restricted concrete construction at the start of the Second

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<sup>36</sup> Hiroshi Watanabe, *The Architecture of Tokyo*, (Kornwestheim, Germany: Edition Axel Menges, 2001), 82.

<sup>37</sup> Arata Isozaki, *Japan-ness in Architecture*, ed. David B. Stewart, (Cambridge, MA: MIT Press, 2006), 9.

Sino-Japanese War in 1937 until the end of World War II in 1945, given the material requirements for total war.

After World War II during the United States post-war Occupation of Japan from 1945-1952, American bureaucrats leveraged their position to build concrete military road systems while encouraging the application of more “modern” materials in Japanese non-residential edifices.<sup>38</sup> At this time, Japanese supported the use of materials other than wood in buildings, too, favoring reinforced concrete wall construction and pre-fabricated designs in rebuilt commercial areas because of the tested methods of resiliency against disaster and because they were presented as a solution to “clearing the existing disorderly built-up areas and creating neatly designed high-rise modern buildings on wide open space.”<sup>39</sup> Furthermore, because most Japanese cities were completely destroyed from firebombing in World War II, pre-fabricated concrete and steel materials allowed for quick assembly.

Another factor that explains the increased use of steel, concrete, and other materials in Japanese buildings is that Japan’s forests were severely depleted in the wake of destructive cutting during the total war effort.<sup>40</sup> Furthermore, between 1930 and 1950, typhoons and other natural phenomenon contributed to the devastation of Japanese forests, impinging domestic wood manufacturing capabilities and severely damaging existing buildings.<sup>41</sup> The sense of a “forest emergency” at the time sparked anxiety over using domestic wood products in Japanese

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<sup>38</sup> O’Bryan, “Hot Infrastructures,” 6.

<sup>39</sup> André Sorensen and Carolin Funck, *Living Cities in Japan: Citizens' Movements, Machizukuri and Local Environments*, (New York, NY: Routledge, 2007), 43.

<sup>40</sup> Yoshi Iwai, *Forestry and the Forest Industry in Japan*, (Vancouver, British Columbia: UBC Press, 2002), 44.

<sup>41</sup> Kabushiki gaisha efu bui gēto, “Nihon no shizen saigai nenpyō,” iFinance no bōsai jihō nabi, [http://www.ifinance.ne.jp/bousai/disaster/saigai\\_japan.html](http://www.ifinance.ne.jp/bousai/disaster/saigai_japan.html).

non-residential buildings, propelling experimentation with other materials during the Occupation years and immediately after.

In preparation for the 1964 Olympics in Tokyo, architects were driven to design tall signature concrete and steel-encased high-rise structures so as to “celebrate Japan's progress and reemergence” on the world stage.<sup>42</sup> Through architecture, Japanese builders and designers wanted to convey that Japan was no longer a wartime enemy, but a peaceful country, and one that was innovative and able to rebound quickly even in the most ruinous of circumstances. In the international edition of the summer 1964 New Architecture (*Shinkenchiku*) journal, it is noted that in hindsight, the failed aspects of buildings in wartime bombings gave architects insightful knowledge that could now be used to build resilient, taller structures.<sup>43</sup> In many ways, to borrow the words of one construction firm, post-war Japan marked the “age of concrete.”<sup>44</sup> This newfound wisdom affected the material choices of architects, engineers, and designers from the 1960s and beyond, emphasizing a preference for integrating reinforced concrete and steel into non-residential structures due to its fire-resistant and anti-seismic nature.

While the application of wood has had a long history in Japanese architecture, in the age of imperialism, to be a conquering hegemony demanded embracing a new social fabric where technological and scientific developments were manifested across all areas of political, economic, social, and cultural development. This included Japanese architecture, where bureaucrats and a new class of architect-engineers eventually accepted that materials found in

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<sup>42</sup> Paul Droubie, “Japan’s Rebirth at the 1964 Tokyo Olympics,” The Japan Society, July 21, 2008 [http://aboutjapan.japansociety.org/content.cfm/japans\\_rebirth\\_at\\_the\\_1964\\_tokyo\\_summer](http://aboutjapan.japansociety.org/content.cfm/japans_rebirth_at_the_1964_tokyo_summer).

<sup>43</sup> O’Bryan, “Hot Infrastructures,” 8.

<sup>44</sup> Ibid., 12.

nature like wood, stone, or bamboo did not command the same authority of an Empire as concrete or steel. Dana Buntrock explains that:

Architecture and engineering emphasized the Japanese Empire's innovation, introducing rail lines and train stations, post offices and schools, offices and art museums- all new building types, constructed in all-new materials, and often inhabited by people in oddly innovative attire. The entire character of public space in society changed in a short time.<sup>45</sup>

Thus, in the opening years of the twentieth century, Japan built structures with the intention of accepting this new paradigm of modernity. In the post-war years, American occupation forces further implanted the belief that materials like concrete and steel were the best option to refashion Tokyo and other cities into modern marvels, showcasing innovation and the ability to rebound.

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<sup>45</sup> Buntrock, 1.

## ***1.2 Wood Not Forgotten: Forestry and Wood Procurement Policies in Post-War Japanese Architecture***

Wood was not entirely abandoned in Japanese architectural plans in the post-war era, however. Between 1955 and 1964, the demand for wood flourished during intensely focused periods of economic recovery, resulting in a rise in wood prices<sup>46</sup> and an increase in the demand for wood production from domestic forests that could not be matched with the rates of afforestation. To account for these surges in demand, primarily in housing industries, the Japanese government decided to implement emergency wood price stabilization measures in 1961 by promptly increasing the amount of imported wood that would be accepted from foreign trade partners.<sup>47</sup> Additionally, policymakers promoted emergency expansion procedures by not only fostering the harvest of national forests and providing financial incentives for private forest owners but by also planting fast-growing conifers to absorb anticipated demand for building materials.<sup>48</sup> At the same time, more products, especially hardwoods,<sup>49</sup> were being imported from outside countries and being implemented in Japan's new construction projects. To further support domestic procurement efforts, the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF) sponsored several activities, such as afforestation support projects and forest conservation projects, to replenish the woodlands depleted during the war.<sup>50</sup>

Entering the decade beginning in 1965, MAFF continued to improve weeding, cutting, and thinning policies for the sake of enhancing the robustness of regrown natural forest stock,

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<sup>46</sup> Shinrin Bunka Kyōkai, "Nihon no mokuzai kakaku no suii," <http://www.shinrinbunka.com/datatable/2-1-04.html>.

<sup>47</sup> Government of Japan, Ministry of Agriculture, Forestry, and Fisheries, *Annual Report on Forest and Forestry in Japan*, Forestry Agency Annual Report Group, (Tokyo, Japan: Policy Planning Division, 2013), 6, <http://www.rinya.maff.go.jp/j/kikaku/hakusyo/25hakusyo/pdf/h25summary.pdf>.

<sup>48</sup> Ibid, 6.

<sup>49</sup> The climatic conditions and the requirement of extremely dense growing environments make it difficult for Japan to grow hardwood species, as is explained in: Fujimori Takao, *Ecological and Silvicultural Strategies for Sustainable Forest Management*, (New York: NY: Elsevier, 2001), 188-189.

<sup>50</sup> *Annual Report*, 2013, 6.

but domestic forestry production activities declined rapidly and there are many factors responsible for this regression that has continued today. One element that impacted the decline of wood in Japanese buildings was a steady increase in price of domestic products.<sup>51</sup> As the yen increasingly gained strength against other global currencies, the demand for overseas wood imports escalated and this demand for foreign imports continues to be high.

Because the costs have been significantly less for architects, engineers, construction companies, and ultimately consumers, price has contributed to Japan being increasingly import-reliant on various wood products – the country is the primary importer of wood chips and plywood, the second largest importer of logs, and third as an importer of lumber.<sup>52</sup> The forest regeneration strategies that started in the 1950s have brought Japanese natural and planted forest stocks to much more stable levels as is seen in Figure 3. These stocks are expanding by one hundred million cubic meters per year, making it an underutilized area of domestic wood product development with great future potential as this forest volume is considerably in excess of Japan's consumption of seventy million cubic meters of wood per year.<sup>53</sup> The government recognizes this, as the “Abe administration plans to double Japan's wood output to thirty-nine million cubic meters by 2020 and raise the share of reliance on domestic sources to fifty percent, from twenty-eight percent now.”<sup>54</sup>

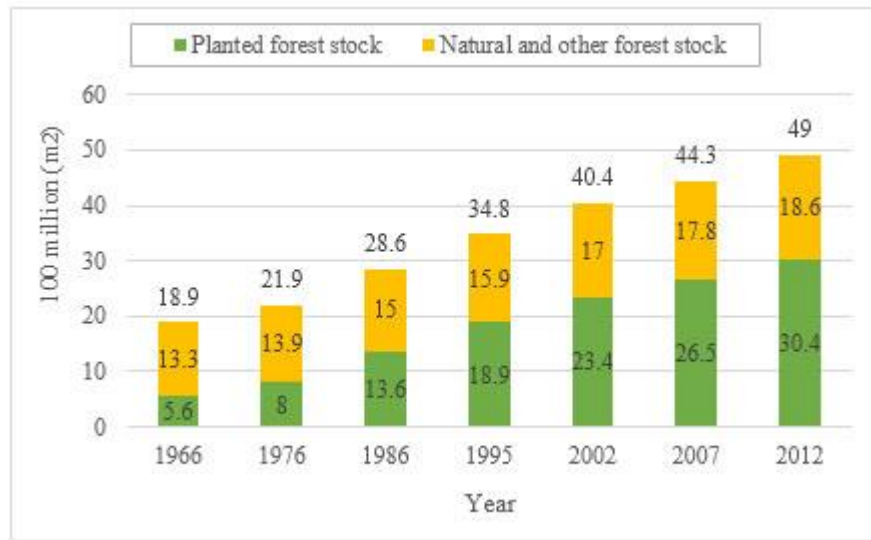
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<sup>51</sup> Shinrin ringyō gakushūkan, “Nihon no ringyō no genjō,” <http://www.shinrin-ringyou.com/ringyou/>.

<sup>52</sup> Hakan Ekstrom, “Japan's Imports of Manufactured Wood Products to Skyrocket due to Post-Tsunami Rebuilding,” *Business Insider*, March 30, 2011, <http://www.businessinsider.com/japanns-imports-of-manufactured-wood-products-to-skyrocket-due-to-post-tsunami-rebuilding-2011-3>.

<sup>53</sup> DeWitt, “Three Cheers for Abe.”

<sup>54</sup> Ibid.



**Figure 3:** Changes in Japan's forest stock from 1966 to 2012.

*Source: Government of Japan, 2013*

Another factor has been the growing preference for materials like concrete and steel in homes, the area that drove the wood industry from 1955-1964, as well as in non-residential structures. From 1965 to 2015, the population in Japanese cities has increased by forty-three percent and is expected to grow substantially more in the future.<sup>55</sup> As a result, high-rise urban apartment complexes, such as the example show in Figure 4, fashioned out of concrete and steel have become more economical for Japanese families, causing overall wood demand in living quarters to steadily decrease. While wooden detached houses made of both non-fireproof and fireproof timbers equal over fifty-six percent of new construction housing stock, these types of housing units are a rarity in megalopolises due to the lack of space.<sup>56</sup> However, eighty percent of

<sup>55</sup> World Resources Institute, "Population, Health and Human Well-being - Urban and Rural Areas: Urban population as a percent of total population,"

<https://docs.google.com/spreadsheets/d/1CN5n085EWsxIKnJBvgGiGFZHtfl-WUCeGyaLehEPI0Q/edit#gid=0>.

<sup>56</sup> Government of Japan, Ministry of Land, Infrastructure, Transport, and Tourism, "Yearly Housing Starts 2014," Excel File, last modified January 30, 2015, accessed from <http://www.e-stat.go.jp/SG1/estat/NewListE.do?tid=000001016966>.



Japanese people continue to prefer living in wooden dwellings, a preference that may be realized for more people if wooden mid- to high-rise housing structures made from EWPs like CLT in Japan become more commonplace.<sup>57</sup>



**Figure 4:** The Riverside Sumida apartment and office complex in Tokyo, Japan is an example of a high-rise reinforced concrete structure in Japanese cities.

*Source: ykanazawa1999, 2009*

A hindrance to establishing more wooden structures in cities is that softwood, the variety of wood most grown in Japan, has not performed well in laboratory tests and in real-life situations in terms of fire resiliency. *Hinoki* and *sugi* are the most used native softwood trees in Japanese buildings, but have historically failed in natural disaster scenarios, which are quite common in Japan. Japanese cities have been plagued with destruction – from the devastating Great Fire of Meireki (1657) to the tremendous eruption of Mount Tambora (1815) to the Great Kantō earthquake (1923) to the firebombing of 64 of Japan’s largest cities by Allied forces during WWII (1941-1945) – where conflagration of wooden houses and buildings have

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<sup>57</sup> Government of Japan, Ministry of Land, Infrastructure, Transport, and Tourism, *Realizing Affluent Residential Living*, Discussion Paper, 2014, 178, <https://www.mlit.go.jp/common/001063085.pdf>.

contributed most to mass destruction and death. The staggering number of collapsed old wooden homes in Kobe after the Great Hanshin earthquake (1995) prompted stipulations for new construction to meet fire-resistance and earthquake-proof requirements, with a preference for materials like concrete and steel.<sup>58</sup> Hardwood, found largely in foreign markets, is required for new construction as it performs more satisfactorily. New wood materials made of hardwood or softwood may only be added to the list of acceptable materials by the federal government once they sufficiently pass rigorous testing, which may take years or even decades.

Public structures made of domestic softwood have performed equally as poorly against fire and other natural forces. Generally, public buildings require higher fire-resistant performance than homes and only wood products that satisfy performance standards can be used. While the cost of wooden public buildings is about equal to reinforced concrete, the total project price tends to become higher due to a lack of past experiences using the mediums, the use of specialized components, and other considerations in design.<sup>59</sup> Despite roughly two-thirds of Japan being forested, approximately eighty percent of wood used in new construction public buildings continues to be from imported sources because imported timber continues to be the cost-efficient alternative in most construction projects. Thus, only twenty percent of wood used in new construction is from domestically produced timber and log products, a move that has forced national and privately owned forests to compete against each other in a very limited domestic market.<sup>60</sup>

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<sup>58</sup>Government of Japan, Ministry of Agriculture, Forestry, and Fisheries, *Annual Report on Forest and Forestry in Japan*, Forestry Agency Annual Report Group, (Tokyo, Japan: Policy Planning Division, 2010), 6, [http://www.rinya.maff.go.jp/j/kikaku/hakusyo/22hakusho/pdf/22\\_e.pdf](http://www.rinya.maff.go.jp/j/kikaku/hakusyo/22hakusho/pdf/22_e.pdf).

<sup>59</sup>*Ibid.*, 6.

<sup>60</sup> Daisuke Tajima, "Forestry in Japan: Solutions for the Future," World Forest Institute, 2010, [http://wfi.worldforestry.org/media/posters/DaisukeTajima\\_Poster.pdf](http://wfi.worldforestry.org/media/posters/DaisukeTajima_Poster.pdf).

For most architects, designers, and policymakers, concrete and steel have been viewed as the most resilient materials against disaster, but this perspective is changing in light of the recently-discovered environmental consequences of using concrete and steel. Concrete is a medium that is heating up cities because the material absorbs heat and slowly expels it back into the atmosphere while the manufacturing of this product has been a main contributor to global gas emissions and energy waste.<sup>61</sup> In order to reduce the environmental impact of concrete, improvements to the production methods of the medium coupled with a shift to using more eco-friendly products will become necessary. Additionally, steel in production phases is one of the main sources of energy waste and releases high amounts of toxic emissions into the atmosphere. While Japanese steel industries have made strides to curb the effects by implementing energy-conserving technologies and equipment,<sup>62</sup> a recent sales tax increase levied on Japanese steel has caused it to be used less in public construction projects, a move that will impact steel use in buildings for many years to come.<sup>63</sup>

Contemporary federal policies signify an acknowledgement that domestic forests and wood products are in need of improvement, especially when used in the public buildings. The Green Purchasing Law (2001 and its 2006 amendment) set in place broad procurement policies targeted at increasing the production and consumption of eco-friendly goods and services. Building on this foundational legislation, the enforcement of the Japanese Wood First Law

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<sup>61</sup> Madeline Rubenstein, "Emissions from the Cement Industry," *State of the Planet: Blogs from the Earth Institute*, Columbia University's Earth Institute, May 9, 2012, <http://blogs.ei.columbia.edu/2012/05/09/emissions-from-the-cement-industry/>.

<sup>62</sup> Japan Iron and Steel Federation, "Japanese Steel Industry Initiatives to Challenge Global Warming," November 2009, 1-4, <http://www.oecd.org/industry/ind/44252021.pdf>. This page from their website details ecological products, processes, and solutions through the use of new steel technologies: <http://www.jisf.or.jp/business/ondanka/index.html>.

<sup>63</sup> Tomono Hiroshi, "Heisei nirokunen shinnen gashikō kankai Tomono kaichō nentō aisatsu," Ippan shadan hōjin Nihon tekkō renmei, January 2, 2014, <http://www.jisf.or.jp/news/topics/140107.html>.

(2010), an act that endorses increased wood use in Japanese public buildings, indicates a shift from a preference for materials like concrete and steel to a push for researching alternatives. Since this law was enacted by MAFF, all twenty-two governmental ministries, all forty-seven prefectures, and most of the one thousand seven hundred and forty-two municipalities have developed and implemented policies for their respective communities that reflect local customs and cultures.<sup>64</sup> Wood, EWPs, and other wood products must now be considered, and, where feasible, must be the primary mediums used in future new-build and refurbishment projects for any government funded projects that are up to three stories high, and for any privately funded structures that are to be used in a public manner, such as elderly care facilities or hospitals. Though these moves have understandably been faced with resistance by those who work in other material industries, architects such as Tadao Ando, Fumihiko Maki, and Toyo Ito have generally embraced wood-concrete hybrid construction in certain contexts, despite being known for their use of reinforced concrete in building designs. Their acceptance of this medium can particularly be seen in interior spaces, where wood adds an element of warmth to the otherwise cold and plain exposed concrete, as is visible in Figure 5. In addition to a degree of architectural acceptance, large firms like Sumitomo Mitsui Corporation and Sumitomo Forestry are partnering to promote uniting materials in building applications, with plans to expand the market of hybrid wood and reinforced concrete into mid- to high-rise buildings in urban centers.<sup>65</sup>

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<sup>64</sup> Mokuzō kōkyō kenchikubutsu zokushinhan, “Shichōson mokuzai riyō hōshin no sakutei jōkyō,” Rinseibu mokuzai riyōka, last revised May 31, 2015, <http://www.rinya.maff.go.jp/j/riyou/koukyou/pdf/sityoson.pdf>.

<sup>65</sup> Sasaki Daisuke, “Sumitomo Ringyō to Mitsui Sumitomo Kensetsu ga teikei: daikibo mokuzō no shijōkaitaku,” *Nihon Keizai Shinbun (Nikkei Shibun)*, January 28, 2015, <http://www.nikkei.com/article/DGXMZO82482640Y5A120C1000000/>.



**Figure 5:** Museum for Wood Culture in Mikata-gun forest, Hyōgo Prefecture, completed by Tadao Ando Architect and Associates in 1994, made from reinforced concrete and *sugi* wood native to Hyōgo.

*Source: FloorNature, 2007*

As the Japanese Empire expanded, extensive destruction and logging of Japanese forests to contribute to the war effort left wood reserves severely depleted. A major part of post-war recovery was MAFF's hand in replenishing national forests to meet demand for wood, particularly in homes destroyed during the war. Special measures were set in place to quickly regrow and expand the area of forests, but when the demand for domestic wood products plummeted in the late 1960s, it left a large part of the natural and planted forest stocks to be unused, a consequence that endures today. Leaders and architects in Japan are starting to realize the potential of reinvigorating domestic wood production to be used in urban structures. While the Wood First Law is limited to public sector buildings, it can be applied across residences and other commercial facilities as well, something that is becoming increasingly more common. For further support, organizations backed by the government such as *Kizukai* (Tree use)<sup>66</sup> and

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<sup>66</sup> This article on the *Kitsukai* website discusses the use of wood for interior designs, advocating that people aged from children to adults understand the importance of using local wood in buildings in contemporary contexts: Kitsukai, "Kitsukai intabyū: Koizumi Makoto," [http://www.kidukai.com/interview/m\\_koizumi/index.php](http://www.kidukai.com/interview/m_koizumi/index.php).

*Mokuiku* (Wood education)<sup>67</sup> are educating the general public on wood use while the Ministry of Land, Infrastructure, Transportation, and Tourism (MLIT)<sup>68</sup> has online access to casebooks, guidelines, and instructions for developers to raise awareness of this medium. The drive for the greater use of responsibly sourced wood from groups such as Japan's Sustainable Green Ecosystem Council, the Forest Stewardship Council, and the Programme for the Endorsement of Forest Certification, are contributing to the larger discussion of contemporary wooden Japanese public buildings. Combined, these systems of Japanese wood encouragement policies, education, and wood certification programs have been educating stakeholders and consumers on the benefits of using wood and on the importance of purchasing locally-sourced and responsibly managed products.

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<sup>67</sup> The *Mokuiku* website is aimed at educating the public on types of wood, crafts, and other activities using wood. In the Q&A Section referenced here, there is information provided on carbon emissions, stating that aluminum consumes about 22 times as much energy as wood in the production phases: Mokuiku, "Yoku aru shitsumon to kaitō," [http://www.mokuiku.jp/qanda/wood\\_q01.php](http://www.mokuiku.jp/qanda/wood_q01.php).

<sup>68</sup> MLIT mokuzai riyō suishinshitsu, "Mokuzai riyō gaidorain/jireishū nitsuite," [http://www.mlit.go.jp/gobuild/moku\\_torikumi.html](http://www.mlit.go.jp/gobuild/moku_torikumi.html).

## **CHAPTER 2: CROSS LAMINATED TIMBER, SUSTAINABILITY, AND RESILIENCE**

This chapter begins by examining the attributes of CLT and then continues on to establish this medium as an example of an EWP that can bridge the gap between resilience and sustainability considerations in building design frameworks. It focuses on the characteristics of CLT that are most in line with ideas associated with resiliency and sustainability. It concludes by affirming that the relationship between sustainability and resiliency is becoming increasingly accepted worldwide, and that the use of CLT and more wood products can reconcile the differences that exist in current systems of building evaluation in Japan.

### ***2.1 Cross Laminated Timber: Opportunities and Barriers***

CLT is a part of a new generation of EWPs known as massive timber, manufactured products that have fibers, veneers, or wood boards glued or bound together with methods of fixation like adhesives, that have been gaining popularity throughout the world in low-, mid-, and high-rise residential and non-residential applications. Though the product was invented first in Switzerland, the technology spread in the 1990s to Austria and Germany as a type of innovative engineered wood paneling, and has since expanded into other markets such as Canada, Australia, the United States, and Japan.<sup>69</sup> As is shown in Figure 6, the material consists of three to seven layers of structural lumber boards typically made from softwoods that are kiln-dried, stacked perpendicular to one another, and then glued together. Applications of CLT can be used for an entire building, in lateral as well as in vertical load resisting systems, or even for select features including the roof, walls, or floors. When integrated into the design and

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<sup>69</sup> Pablo Crespell and Sylvain Gagnon, *Cross Laminated Timber: A Primer*, Vancouver, British Columbia: FPInnovations, 2010, 1, <https://fpinnovations.ca/media/factsheets/Documents/cross-laminated-timber-the-boook.pdf>.

construction industries of Japan, CLT can be a wood-based solution that complements the two existing timber frame options for homes and public structures: post-and-beam and 2 x 4. This section provides basic information on the various attributes of CLT to establish this product in the broader milieu of material selection and architecture in Japanese urban history.



**Figure 6:** Cut sample size of two sets of CLT available for purchase.

*Source: Nihon CLT Kyōkai*

CLT's many attractive features have sparked an increasing amount of interest in recent years, as architects and engineers have been evaluating the opportunities of this medium in widespread construction contexts. One noteworthy characteristic of CLT is its **design flexibility**. Because CLT is typically manufactured for specific purposes, meaning the panels are prefabricated then sent to a site allowing for rapid assembly, it is easy for manufacturers to increase thickness and cut openings to exact specifications when needed. EURBAN, a timber engineering company that was responsible for providing the CLT panels used to assemble the Bridport House in London in 2011, estimated that on-site assembly time was fifty percent faster than what is typical of reinforced concrete.<sup>70</sup> Additionally, CLT can be combined with wood frames, a variety of wood products like glued laminated timber (glulam) beams, and with other

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<sup>70</sup> *Bridport House Case Study*, Willmott Dixon, 2011.



materials like concrete or steel, enabling flexibility in architectural style. Moreover, because CLT panels weigh less than concrete or steel, the costs normally incurred when building a structure's foundation and framing can be significantly reduced. While light wood 2 x 4 frame construction continues to be the most cost efficient wood system for low-rise building projects, a 2010 study conducted by FPInnovations found that CLT is price competitive when compared to building materials like concrete, masonry, steel, and other timber products.<sup>71</sup>

**Environmental advantages**, such as the fact that wood is a renewable resource, are inherent benefits that other conventional materials do not have. When harvested from ethically managed forests, wood used in CLT and other wood products can be regrown to be used again in future building applications. In addition, life cycle assessment studies have consistently shown that wood outperforms steel and concrete in terms of embodied energy, solid waste, air pollution, and water pollution (*See Figures 7 and 8*). Wood and EWPs also have lighter carbon footprints because wood products are carbon sinks, meaning the wood removes carbon dioxide even after being cut from the atmosphere and stores it within building components.<sup>72</sup> Wood manufacturing also requires less energy and results in less greenhouse gas emissions through all stages of production and construction.<sup>73</sup> Furthermore, since CLT panels are designed for specific building applications, there is little to no waste on-site during assembly. In the event there is waste, manufacturers can reuse leftover parts for architectural elements like stairs, or even as biofuel.<sup>74</sup>

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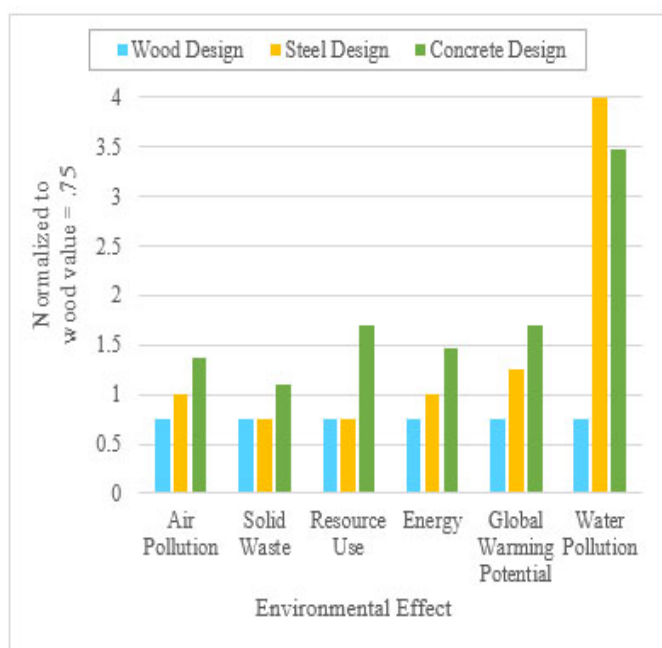
<sup>71</sup> Crespell and Gagnon, 19-21.

<sup>72</sup> Michael C. Green, "The Case for Tall Wood Buildings: How Mass Timber Offers a Safe, Economical, and Environmental Friendly Alternative for Tall Building Structures," mgb Architecture + Design, February 22, 2012, 26-27. <http://www.cwc.ca/documents/Industry/Tall%20Wood%20Buildings%20-%20Final%20Report.pdf>.

<sup>73</sup> This whole report is a summary on the consensus of scientific literature on topics related to wood use and production: Roger Sarthe and Jennifer O'Connor, *Synthesis of Research on Wood Products & Greenhouse Gas Impacts*, Vancouver, British Columbia: FPInnovations, 2010, <http://www.woodworks.org/wp-content/uploads/FPI-Greenhouse-Gas.pdf>.

<sup>74</sup> "Cross-laminated Timber (CLT) Offers a New Building System Option for Non-Residential and Multi-Family Construction," WoodWorks, 4, <http://www.woodworks.org/wp-content/uploads/CLT-Solid-Advantages.pdf>.

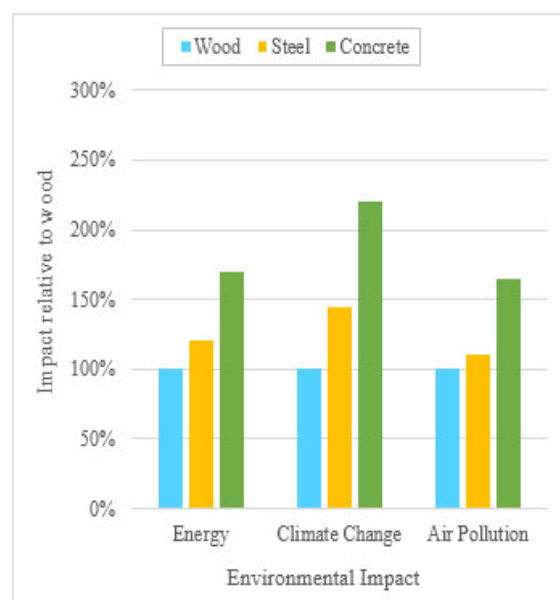
Additionally, thermal performance and energy efficiency of CLT can be optimized depending on the thickness of the panel. The U-value, or coefficient of heat transfer, is what measures thermal performance for building elements. When a thicker panel has a lower U-Value, it is a better insulator and since CLT panels can be prefabricated to fit precisely together, this results in better energy efficiency and little potential airflow in and out of a structure. As a result, it is possible for only one-third of the energy required for normal heating and cooling functions to be used in a finished CLT building to maintain interior temperatures.<sup>75</sup>



**Figure 7:** Embodied effects relative to wood design across all measures

This graph compares the environmental effects of three hypothetical home designs of identical size and configuration for the first 20 years of operation.

Source: Canadian Wood Council



**Figure 8:** Embodied environmental impacts of exterior wall assemblies

This graph compares three building materials used in exterior walls in terms of environmental performance in three categories.

Source: FPInnovations

<sup>75</sup> Canadian Wood Council, *A Strategic Plan for the Commercialization of Cross-Laminated Timber in Canada and the US*, 2010.

Traits that enhance a structure's **natural disaster protection and performance** are the final attributes that make CLT and other EWP's unique. CLT has a thick cross-section that enables panels to char on the outside and panels are coated with chemicals to prevent moisture from entering, protecting the internal wood elements from degradation. This ensures a relatively high level of fire and water resiliency in natural disaster scenarios. As the panels are prefabricated, often there are less concealed spaces, a feature that reduces the likelihood of a fire spreading undetected.<sup>76</sup> In addition, due to the dimensional stability and rigidity of CLT panels, they effectively can resist lateral loads, offer good ductile performance, and are able to dissipate energy when faced with seismic tremors. Researchers have performed extensive seismic testing on CLT to find that panels perform exceptionally well with little to no residual deformities; this is particularly true in multi-story applications.<sup>77</sup> To protect against vermin, insect, or mold infestations from occurring, kiln dried timber with a wood humidity of twelve percent (+/- two percent) is exclusively used. The cross-wise arrangement of the wooden slabs also contributes to the reduction of moisture expansion and shrinkage.<sup>78</sup>

While there are many positive attributes associated with CLT, there are also barriers to the application of CLT in buildings. The first is acoustic performance, as wood naturally transfers sound easily. CLT building systems provide adequate, but not excellent, noise control coverage leading builders to frequently add sealant and other types of membranes like sleeper studs or wall coverings to provide air tightness and improve sound insulation.<sup>79</sup> The application

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<sup>76</sup> WoodWorks, 4.

<sup>77</sup> Crespell and Gagnon, 7-9.

<sup>78</sup> Holger Giebel and Sandro Mainusch, "TimberTowers for Wind Energy Plants of the Multi-Megawatt Class," (presentation in Hannover, Germany, 2006), 11, [http://www.puuinfo.ee/pdf/konv\\_PuitHomseElukeskVoti09/HolgerGiebelSandroMainusch.pdf](http://www.puuinfo.ee/pdf/konv_PuitHomseElukeskVoti09/HolgerGiebelSandroMainusch.pdf).

<sup>79</sup> Sylvain Gagnon and Ciprian Pirvu CLT Handbook, Québec City, Québec: FPInnovations, 2011, 4-39. <https://fpinnovations.ca/Pages/CltForm.aspx>.

of extra wall plates increases the overall system thickness, causing walls to be approximately one hundred and fifty millimeters (six inches) thicker than concrete.<sup>80</sup> Additionally, the distance CLT is able to span is one of its primary limitations. Since CLT is a solid panel system, its integration will typically need extra attention when hidden inside wall cavities and its limited spans results in a structural system that is more ideal for offices or multi-family housing rather than other large complexes such as factories. Furthermore, since the product is made up of wood, it requires special consideration in construction as well as fire protection during assembly. To operate most effectively, the system is unable to get wet *during* construction so measures to protect it from weather conditions are necessary.<sup>81</sup>

While there are challenges to the application of CLT to public structures, the design flexibility, environmental advantages, and natural disaster protection and performance CLT and other wood products offer outweigh the obstacles presented by its resiliency and its sustainability. Further research can be done to overcome obstacles in implementing CLT.

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<sup>80</sup> Jason Schmidt and Corey T. Griffin, “Barriers to the Design and Use of Cross-laminated Timber Structures in High-Rise Multi-Family Housing in the United States,” 1-3, [http://web.pdx.edu/~cgriffin/research/jschmidt\\_clt.pdf](http://web.pdx.edu/~cgriffin/research/jschmidt_clt.pdf)

<sup>81</sup> Schmidt and Griffin, 1-3.

## ***2.2 Bridging the Gap with CLT: Discourse on Sustainable and Resilient Wood Design***

In recent years, “sustainability” is a word that has received an increasing amount of attention by governments and individuals seeking to maximize resources without wasting, damaging, or depleting them. On the surface, it is a simple concept, and when considering the many ways in which sustainability affects the world, such as with building material choices, it becomes increasingly complex. Sustainable design is an essential component to sustainable development, which according to the often quoted Brundtland report is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”<sup>82</sup> in the environmental, economic, and social arenas. Because buildings have relatively long life spans, reducing their impact will usher abundant ecological, economic, and social benefits. Sustainable design

seeks to reduce negative impacts on the environment, and the health and comfort of building occupants, thereby improving building performance. The basic objectives of sustainability are to reduce consumption of non-renewable resources, minimize waste, and create healthy, productive environments.<sup>83</sup>

Following the United Nations Framework Convention on Climate Change (1992) and the Kyoto Protocol (1997), Japanese local and national governments, together with corporations, manufacturers, and professionals in the architecture, engineering, and construction industries have taken on greater responsibility to reduce toxic emissions, conserve resources, and create stronger domestic markets in order to improve ecological “footprints” and meet national emission reduction commitment goals. This increased concern has guided many policymakers,

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<sup>82</sup> World Commission on Environment and Development (WCED), *Our Common Future*, (Oxford: Oxford University Press, 1987), 43.

<sup>83</sup>United States General Services Administration, “Sustainable Design,” last modified June 1, 2015, <http://www.gsa.gov/portal/content/104462>.

architects, and other professionals to reconsider wood and EWPs in building applications. In broader terms, these anxieties have also led to the emergence of building assessment and rating systems like the Leadership in Energy and Environmental Design (LEED) in the United States and the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in Japan as well as the formation of Japanese organizations like the Japan Sustainable Building Consortium (JSBC) and the Institute for Building Environment and Energy Preservation (IBEC) who, with the support of the Building Center of Japan (BCJ) and MLIT, evaluate such items as energy use, greenhouse gas emissions, water use, materials, waste, and indoor environment through all phases of production. These measurement tools consider all processes involved for building materials-- from the manufacturing of products, the assembly, the lifespan and interior performance of the building, and finally the demolition-- in terms of sustainable benchmarks established within respective frameworks.

Since buildings account for more than forty percent of global energy use and thirty percent of global greenhouse gas emissions,<sup>84</sup> public discourse has generally focused on mitigation strategies to prevent further release of energy, emissions, and waste into the atmosphere and world ecosystems. Sustainable design should not be thought of as a utopian end state, but rather, through the application of innovative, dynamic techniques and materials, structures built with adaptable design will be equipped with the foresight to face future uncertainty. In line with this mode of thinking, recent discussions have centered on how

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<sup>84</sup> United Nations Environment Programme, *Buildings and Climate Change: Summary for Decision-Makers*, Sustainable Consumption and Production Branch, Paris, 2009, 3, <http://www.unep.org/sbci/pdfs/SBCI-BCCSummary.pdf>.

resilience can become the new driver of sustainability in building design as well as in other fields of economic, social, and environmental development.<sup>85</sup> Resilience is

the capacity to adapt to changing conditions and to maintain or regain functionality and vitality in the face of stress or disturbance. It is the capacity to bounce back after a disturbance or interruption as well as the intentional design of buildings, landscapes, communities, and regions in response to these vulnerabilities.<sup>86</sup>

A current, more ecological definition acknowledges that resilience is not only the ability for a structure to rebound back after a disturbance, interruption, or stress, but also the ability for a building to adapt to changing conditions, known as the structure's adaptive capacity.<sup>87</sup> This means that the skeletal framework and the components of a building's design must also be adaptable, durable, and reusable in order for people to safely live and work in stable communities. Wood and EWP's are able to withstand natural disasters as well as ensure longevity despite the inevitable fluctuations in societal aesthetic preferences and values.

Many of the strategies studied and employed by architects and structural engineers to achieve resilience in buildings - such as utilizing light wood framing in buildings to provide flexibility - are exactly the same strategies that have been utilized in the sustainable building movement for different purposes. In this situation, the structural engineer's primary concern is to develop a scaffold that resists seismic tremors while an architect's main goals when designing green is to select a material that is affordable, produces minimal amounts of waste and energy loss through all phases of production, is attractive to consumers, and is renewable. The

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<sup>85</sup> For instance, the Resilience 2014 Conference had over 900 attendees who discussed topics related to resilience planning, resilience design, and resilient cities in relation to urban systems and environmental services.

<sup>86</sup> Resilient Design Institute, "What is Resilience?" *Resilience Design Institute Blog*, <http://www.resilientdesign.org/what-is-resilience/>.

<sup>87</sup> Timon McPhearson, "The Rise of Resilience: Linking Resilience and Sustainability in City Planning," *The Nature of Cities*, June 8, 2014, <http://www.thenatureofcities.com/2014/06/08/the-rise-of-resilience-linking-resilience-and-sustainability-in-city-planning/>.

motivation for the former is life-safety, while economic, social, and environmental efficiency guide the later. Under the basic premise that a building must be resilient in order to be truly sustainable, resilient design is increasingly being examined from the standpoint of sustainable design.

Indeed, the solutions are largely the same, but current worldwide systems of assessment and rating for buildings treat sustainability and resilience as separate measurements that are often evaluated by separate organizations. In Japan, the BCJ is the main organization in charge of measuring the resiliency of buildings. Designated by the MLIT, BCJ primarily carries out performance evaluations of wooden buildings under the amended Building Standard Law of 2000 and, since 2010, provides certifications for seismic assessments as well. By law, there are seismic performance specifications that vary depending upon the material used for all new constructions while efforts are underway to renovate existing public buildings and homes to meet the requirements outlined in the Building Standard Law. Sustainability criteria, however, is completely voluntary but the government and businesses offer incentives to encourage sustainable development. While the BCJ does award CASBEE certifications, IBEC continues to be the principal nonprofit group that conducts CASBEE tests and awards certificates. A singular, holistic approach centered on combining goals of sustainability and resilience into *one* framework evaluated by *one* organization will ensure environmentally-friendly and safe public structures.

As the interconnectedness of these two concepts is becoming more accepted worldwide, societies are being educated on sustainable and resilient design through universities, books, and public culture outlets. Janis Birkeland in a chapter from *Resilient Sustainable Cities: A Future* offers a solution called Eco-positive Design Report (EDR), an integrative approach to



implementing eco-technologies and services in buildings where design professionals, scientists, and engineers all work together in the construction process with a focus on achieving positive improvements to urban environments and future adaptability, or resilience.<sup>88</sup> Several institutions of learning now offer programs, like the Sustainable and Resilient Infrastructure Systems Program at the University of Illinois,<sup>89</sup> while the best-selling book *Resilience: Why Things Bounce Back*, by Andrew Zolli and Ann Marie Healy examines how resilience can be used to assess all areas of societal development including urban infrastructure.<sup>90</sup> Recently, there have been articles in academic journals and newspaper sources like the Huffington Post<sup>91</sup> and the New York Times<sup>92</sup> that discuss the importance of reevaluating resilience in terms of sustainability and ask if “resilience, coupled with sustainable design, [will] encourage the construction of higher-quality buildings and infrastructure with a longer-term view?”<sup>93</sup> These types of questions are prime movers for change, demonstrating a greater understanding that achieving measured sustainability in a structure is a long-term goal and that permanent, resilient buildings capable of withstanding disaster, time, and evolving cultural preferences are possible, especially using wood and EWP applications

CLT is a material that can bridge this gap because its design flexibility, environmental advantages, and natural disaster protection and performance are consistent with Japanese

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<sup>88</sup> Janis Birkeland, “Systems Design and Social Change for Resilient, Sustainable Cities” in *Resilient Sustainable Cities: A Future*, eds. Leonie Pearson, Peter Newton, and Peter Roberts, (Abington, UK: Routledge, 2014), 75-76.

<sup>89</sup> University of Illinois Urbana-Champaign, College of Engineering, The Department of Civil and Environmental Engineering, Sustainable and Resilient Infrastructure Systems Program, <http://cee.illinois.edu/SRIS>.

<sup>90</sup> Andrew Zolli and Ann Marie Healy, *Resilience: Why Things Bounce Back*, (New York, NY: Simon & Schuster, 2013), 93-117.

<sup>91</sup> Sunmin Kim, “Sustainability vs. Resilience: Don’t Give up Yet,” *Huffington Post*, January 22, 2013, [http://www.huffingtonpost.com/sunmin-kim/sustainability-vs-resilie\\_b\\_2526849.html](http://www.huffingtonpost.com/sunmin-kim/sustainability-vs-resilie_b_2526849.html).

<sup>92</sup> Andrew Zolli, “Learning to Bounce Back,” *The New York Times*, November 2, 2012, <http://www.nytimes.com/2012/11/03/opinion/forget-sustainability-its-about-resilience.html>.

<sup>93</sup> Blaine Brownell, “Is Resilience the New Sustainable Design?” *The Journal of the American Institute of Architects*, October 30, 2012, [http://www.architectmagazine.com/technology/is-resilience-the-new-sustainable-design\\_o](http://www.architectmagazine.com/technology/is-resilience-the-new-sustainable-design_o).

sustainability and resilience agendas. The current systems in place for manufacturing and applying other conventional materials like concrete or steel to Japanese residential and non-residential buildings are unable to contribute less to climate change, air pollution, and energy waste like wood while CLT and other EWPs are engineered to resist fire, water, and other natural phenomena damage as well as other mediums. CLT remains a product not yet integrated in the Japanese market, but the trend is that wood and other EWPs are increasingly being used in contemporary Japanese public structures.

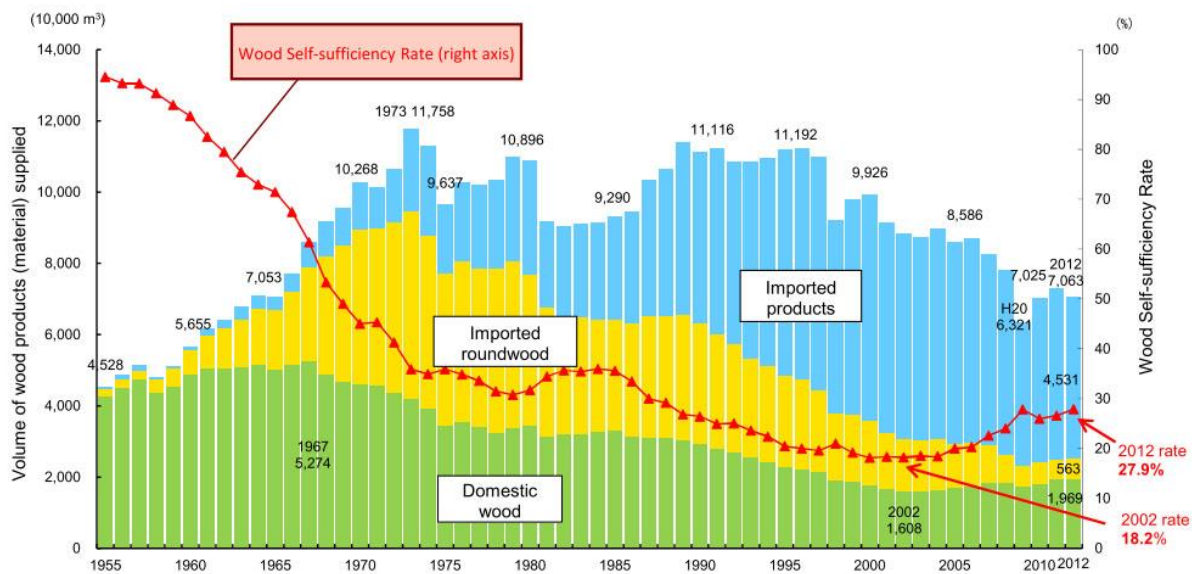
## **CHAPTER 3: WOOD BUILDINGS AND THE FUTURE**

This chapter underscores that wood and EWPs are already being used in creative applications. It then details the support for CLT in Japan as well as the research that has been done on CLT in Japan and other global contexts. Shigeru Ban and Kengo Kuma are two architects who have been advocating increased use of wood or wood-derived products in urban contexts and have extensively used these mediums in a variety of public and residential projects, demonstrating that such products are viable alternatives in light of their resiliency and lower environmental impact. Moreover, the formation of groups such as the Japanese CLT Association (*Nihon CLT Kyōkai*) and burgeoning support of CLT in research programs such as the SOPHIE Project further demonstrate that CLT, as well as other wood products, are on the brink of revolutionizing urban landscapes. This chapter concludes with an acknowledgement that a revival of CLT and wooden architecture is an integral part of a broader history of material culture in Japan.

### ***3.1 Contemporary Urban Japan: Wood Design and Wood Products***

In light of global dialogue reconsidering how to design buildings while acknowledging that sustainability and resilience are connected paradigms - coupled with domestic initiatives in Japan - wood procurement, forestry revitalization, and wood product manufacturing have become topics of interest in the country. Building on earlier strategies enforced by the Japanese government, the “Plan to Create Dynamism through Agriculture, Forestry, and Fisheries and Local Communities” (2013) states that “forestry will be made a growth industry through the

creation of new wood demand and building of a stable and efficient supply scheme,”<sup>94</sup> an initiative that is gradually pushing Japan to becoming a more independent wood producing country. Figure 9 shows that after decades of decline in domestic production of wood, there has generally been a slow increase since the early 2000s while a surge in the self-sufficiency rate indicates increased supply of domestic wood products for various applications. Indeed, government policies and educational initiatives are influencing Japanese architects, engineers, and designers who are now beginning to merge aspects of sustainability and resiliency into their wooden building designs. Many professionals are assessing how EWP can be used to contribute to the optimal long-term performance and resiliency of structures, to reduce the environmental impact of structures, and to support the growth of local wood-based production economies.



**Figure 9:** Changes in wood supply and demand and the self-sufficiency rate for wood

Source: Government of Japan, 2013

<sup>94</sup>Annual Report, 2013, 23.

Since the 1990s, and most pronouncedly since in the 2000s, the application of wood, wood-based products, and EWPs in public structures has become more common. As discussed in the first chapter, this is because government agendas have shifted focus towards environmental and energy policies and regulations. Moreover, the formation of new groups like the Japan Laminated Wood Products Association (*Nihon Shūsei Zaikō Gyōkyō Dōkumiai*) demonstrate that knowledge and domestic production of EWPs and wood is spreading nationwide. The trend of adding wood products to design projects can be seen in recent works by Naito Architects and Associates as seen in the Toba Sea Folk Museum (1993), Taira Nishizawa with his work Church Sun-pu (2010), and Takenaka Corporation's recent Southwood Mall (2013) in Yokohama, a structure built with one hundred and seventy *karamatsu* (Japanese larch) trees that were tested under a one-hour fire-resistance testing certification process.<sup>95</sup>

Furthermore, the distinctive headquarters of the Tokyo Lumber Wholesalers Association (*Mokuzai Kaikan*) designed by Nikken Sekkei Ltd. as show in Figure 10 is one that particularly “serves as a showcase to demonstrate the possibilities of wood as an urban construction material.”<sup>96</sup> The design integrates *engawa*, or Japanese terraces, to permit natural breezes to enter while dissipating strong sunlight to create a comfortable interior space. A large amount of *hinoki* is used on both the interior and exterior, and great care was given to ensure excellent fire-safety.

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<sup>95</sup> Fujita Kaori, “Nijūnijūnen, Tōkyō ga ‘mokuzō biru no mori’ ni kyōgaku no shinkōhō,” *Nikkei Shinbun*, October 9, 2014, 1, <http://www.nikkei.com/article/DGXMZO78149080Y4A001C1X93000/>.

<sup>96</sup> Nikken Sekkei Ltd., “Mokuzai Kaikan,” <http://www.nikken.co.jp/en/projects/office/midrise/mokuzai-kaikan.html>.



**Figure 10:** Mokuzaikai Kaikan structure in Tokyo, Japan built by architect Tomohiko Yamanashi in 2009.

*Source: Nikken Sekkei Ltd., 2009*

While this is just one example of the application of EWPs in a metropolitan environment, two architects stand out in Japan as major proponents who have championed the revival of wood products in cities: Shigeru Ban and Kengo Kuma. **Shigeru Ban**, the winner of the prestigious Pritzker Prize in 2014, is an architect that primarily uses wood products for his projects. In response to the Great Hanshin earthquake (1995) disaster that struck Kobe, architect Ban commented that “it is rare for people to die from the earth shaking beneath them. People die because they are crushed underneath collapsing buildings.”<sup>97</sup> Ban’s criticism of buildings, artifacts of human agency, as the cause of these deaths and destruction and not solely the geological phenomenon itself is clear. Ban has redefined architectural aesthetics, materials, and structure through the use of the EWPs of paper tubing and paperboard, derivatives of wood that he often salvages from recycled, reclaimed items.<sup>98</sup> Ban asserts that inherently weak materials such as these do not necessitate poor construction but rather, the application of glue, wax-

<sup>97</sup> Matilda McQuaid and Ban Shigeru, *Shigeru Ban* (London ; New York: Phaidon, 2003), 22.

<sup>98</sup> Shigeru Ban, “Eco-Architect and Three-Dimensional Poet,” *TedxTokyo* video, 12:58, May 12, 2013, [https://www.youtube.com/watch?v=IjHlyKT\\_Uug](https://www.youtube.com/watch?v=IjHlyKT_Uug).

coatings, urethane solutions, or other weather-proofing chemicals by engineers and architects has enabled timber and tubes to be durable as well as ecologically viable mediums for use in public sector buildings as well as in residences.<sup>99</sup> Through these chemical technologies, tubes effectively become fire and water-resistant, making them a cost effective material that can be used in many different types of structures.<sup>100</sup> These paper tubes can then be cut to be any length, diameter, or thickness and once cut, the tubes can be saturated with glue, wound around metal rods to shape, and then the rods can be removed to create a hollowed-out core.

Proving the resiliency, safety, and environmental benefits of paper products to local and federal governments, architects, engineers, and consumers was a challenge that took Ban several years to overcome. In experimental projects like Emilio Ambasz's exhibition in Tokyo (1985), Ban's Paper Arbor in Nagoya (1989) at a World Design Exposition, and Ban's Library of a Poet (1991), Ban carefully measured the compressive strength of paper tubes, the effects of humidity and other weather patterns on paper tubes, and long-term behavior of paper tubes under constant weight. Backed with determination and scientific evidence, Ban was able to prove the strengths of paper tubing and, by 1993 under a revision to the Building Standard Law, the use of these unconventional objects in public and private structures was approved. Henceforth, certain paper products were considered legitimate materials for construction, evaluated as sufficient in terms of safety, compressibility, expansibility, flexibility, and overall durability to the same degree as other conventional mediums like certain types of wood, concrete, or steel.<sup>101</sup>

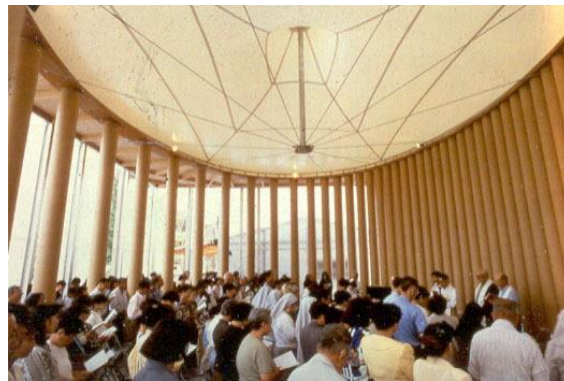
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<sup>99</sup> McQuaid, 11-14.

<sup>100</sup> Ban Shigeru, *Kami no kenchiku kōdō suru: Shinsai no Kōbe kara Ruwanda nanmin kyanpu made*, (Tōkyō: Chikuma shobō, 1998), 60.

<sup>101</sup> McQuaid, 14.

The first project Ban was able to create under this revision was the Paper Church and the Paper Log homes in Minamikomae Park in the wake of the Great Hanshin earthquake. In a less wealthy area of Kobe that was not a priority zone for recovery under reconstruction plans,<sup>102</sup> Ban's Paper Church helped to restore not only social resiliency within the community but also was built to resist any other future earthquake tremors and was paired with sustainable features. The center was constructed in the shape of an ellipse to create intimacy while the outside and inside could be united by opening shutter-like doors, allowing for flexibility with multiple uses of the space.<sup>103</sup> The shutter-like doors could also be adjusted to protect against harsh weather conditions or left completely open for increased ventilation.<sup>104</sup> Moreover, the oval-shape made of polycarbonate tent material allowed natural sunlight inside and emitted a golden glow at night, requiring only minimal electricity (*See Figure 11*).



**Figure 11:** The Paper Church in Kobe, Japan built by Shigeru Ban in 1995.

*Source: Shigeru Ban Architects, 1995*

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<sup>102</sup> David W. Edgington, *Reconstructing Kobe: The Geography of Crisis and Opportunity* (Vancouver, BC: The University of British Columbia Press, 2010), 77-91.

<sup>103</sup> Norman K. Booth, *Foundations of Landscape Architecture: Integrating Form and Space Using the Language of Site Design* (Hoboken, NJ: John Wiley & Sons, Inc, 2011), 303-316.

<sup>104</sup> Shigeru Ban, Eugenia Bell, and Deb Wood, *Shigeru Ban*, (New York, NY: Princeton Architectural Press, 2001), 101.



Shigeru Ban's influence extends well beyond Japan. One structure built entirely of wood and EWPs, without even the use of steel reinforcement to connect wood beams, and encased in a glass façade as shown in Figure 12, is the Tamedia Office Building in Zürich, Switzerland. The prefabricated, precision milled timber elements were created in a manufacturing center and assembled on site.<sup>105</sup> Moreover, the use of spruces grown in nearby Styria, Austria helped to reduce emissions during the construction phases.<sup>106</sup> To support afforestation, these trees used for the project were replanted. Tamedia Office Building demonstrates not only that timber construction technologies have matured, but that it is possible for whole wood structures to be designed in structurally sound and sustainable ways.



**Figure 12:** Tamedia Office Building in Zürich, Switzerland built by Shigeru Ban in 2013.

*Source: Tamedia, 2013*

The efforts of Shigeru Ban have enabled other architects, such as **Kengo Kuma**, to have access to EWPs that are being applied to their building designs. Kuma is another architect who often utilizes ancient Japanese techniques of joinery and wood-working to create new buildings

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<sup>105</sup> Ulf Meyer, "Tamedia Office Building," Arcspace.com, January 16, 2014, <http://www.arcspace.com/features/shigeru-ban/tamedia-office-building/>.

<sup>106</sup> Tamedia, "The New Tamedia Building," <http://www.tamedia.ch/en/company/tamedia/the-new-tamedia-building/>.

and his material choices often reflect a desire to conform to natural surroundings. Kuma's goal is to use advanced technologies of today, with materials like wood to achieve a type of fusion that bridges notions of traditional and innovative.<sup>107</sup> Kuma states that:

Concrete [can look] fairly attractive, but my other senses, accustomed to the house in which I had grown up, [are] unable to adapt to the idea of the raw concrete box...Perhaps it is no exaggeration to say that...my professional career has been focused on a single goal: escaping the clutches of concrete.<sup>108</sup>

When possible, Kuma uses products near the work site and he is committed to not only preserving nature, but also to retrofitting and renovating buildings that already exist to save on money, costs, and environmental impacts associated with demolition and reconstruction.<sup>109</sup> Especially after the March 11, 2011 Great East Japan earthquake and tsunami disasters, Kuma felt an "extreme imbalance of power between nature and buildings" which caused him to believe that other architects should forgo the use of industrial materials and accept a more humble approach to architecture through the use of timber, bamboo, and other naturally-occurring materials that can be regrown.<sup>110</sup> Kuma is also a proponent of using other organic materials in creative ways, such as adobe, ivy, and other plants.<sup>111</sup>

Kuma's approach to architecture can be seen in Figure 13, the Daiwa Ubiquitous Computing Research Building, constructed as a part of the University of Tokyo's campus with the "aim to break away from the conventional image of campuses that consist of hard materials

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<sup>107</sup> Bogнар Botond and Kengo Kuma, *Kengo Kuma: Selected Works*, (New York, NY: Princeton Architectural Press, 2005), 17.

<sup>108</sup> Bogнар Botond, *Material Immaterial: The New Work of Kengo Kuma*, (New York, NY: Princeton Architectural Press, 2009), 38.

<sup>109</sup> Botond, *Material Immaterial*, 39.

<sup>110</sup> James Pallister, "Kengo Kuma urges architects to 'be humble'", *DeZeen Magazine*, March 11, 2014, <http://www.dezeen.com/2014/03/11/kengo-kuma-interview-architecture-after-2011-japan-tsunami/>.

<sup>111</sup> Botond, *Material Immaterial*, 34.

like concrete, metal, or stone, and instead design a soft building made with wood and earth.”<sup>112</sup>

These scale-like types of EWPs are designed and arranged at irregular heights on the façade and spaced apart enough to allow natural sunlight to enter the interior of the structure. The Japanese garden in the front generates a flow of light and wind into the building and works as a connector of exterior and interior spaces.



**Figure 13:** The Daiwa Ubiquitous Computing Research Building in Tokyo, Japan built by Kengo Kuma in 2014.

*Source: Kengo Kuma and Associates, 2014*

Moreover, Kuma’s Yusuhara Town Hall (2006) in Kōchi Prefecture, uses locally sourced *sugi* trees in order to further promote a positive architectural relationship with nature and is the largest wooden town hall in Japan.<sup>113</sup> It was designed to exist with the environment, not merely in it, because in Kuma’s words: “the environment itself changes every day...I don’t worry about the change of the environment, because I always try to make the building as flexible as it can be

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<sup>112</sup> Kengo Kuma and Associates, “Daiwa Ubiquitous Computing Research Building,” <http://kkaa.co.jp/works/architecture/daiwa-ubiquitous-computing-research-building/>.

<sup>113</sup> Kengo Kuma and Associates, “Yusuhara Town Hall,” <http://kkaa.co.jp/works/architecture/yusuhara-town-hall/>.

to embrace variety.”<sup>114</sup> Kuma understands that designing structures that are durable and resilient in a variety of circumstances is as crucial to the building’s performance as is the application of wood and EWPs for aesthetic and practical reasons. The indoor and outdoor plazas are separated by large sliding doors but can become one space when needed for events such as festivals and with consideration of bad weather conditions, Kuma designed a large atrium so that businesses like banks and the Chamber of Commerce can have facilities that are more easily accessible for town residents (*See Figure 14*).<sup>115</sup>



**Figure 14:** Yusuhara Town Hall in Kōchi Prefecture built by Kengo Kuma in 2006

*Source: Kengo Kuma and Associates, 2006*

Architecture, engineering, and construction industries are changing because of governmental and educational policies focused on the application of wood and EWPs in public buildings in cities. Shigeru Ban and Kengo Kuma are two of the main architectural stimuli in Japanese society for this shift *back* to using wood and EWPs now that new technologies are available to improve the performance of these mediums that have long been regarded as weak

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<sup>114</sup> Ariel Genadt, “Q+A Kengo Kuma Au Naturel,” *The Architects Newspaper*, February 2, 2012, [http://archpaper.com/news/articles.asp?id=5870#.VVVBG\\_IViko](http://archpaper.com/news/articles.asp?id=5870#.VVVBG_IViko).

<sup>115</sup> Kengo Kuma and Associates, “Yusuhara Town Hall.”

and ill-suited for public building contexts. Their works, as well as such works as Southwood Mall and the Mokuzai Kaikan building, demonstrate that it is possible for EWPs to have a sustainable and resilient design. In Japan, CLT takes this one step further by being a material made predominantly from softwood, which is a major reason why CLT has the potential to revitalize Japanese forests and domestic wood production markets.

### ***3.2 New Directions: Cross Laminated Timber and Engineered Wood Products in Cityscapes***

EWPs as alternatives to conventional construction are gaining prominence in urban landscapes due to factors such as stability, uniformity, and guaranteed performance in buildings. This trend is particularly visible in the Japanese housing market, where up to eighty-six percent of the imported EWP glulam is estimated to be used in Japanese post-and-beam homes.<sup>116</sup> In the public building sector, the rate of growth is much slower, but it is projected that EWPs, like glulam and CLT, will soon have a significant impact on non-residential structures in Japan. In the Wood First Law, CLT is considered one of the most promising structural components that can be applied to non-residential large-scale wooden edifices.<sup>117</sup> Although only less than eight percent of public buildings in Japan are wooden,<sup>118</sup> MAFF has expressed that “new products and technologies such as CLT among others...will be used to pave the way toward ‘woody cities’.”<sup>119</sup> This mode of thinking was further developed and validated following the completion of a dormitory in Ōtoyo Town, Kōchi Prefecture in 2014, making this building the first Japanese CLT structure, as shown in Figure 15. Furthermore, because CLT is made from softwood trees, which are in ample supply in Japan, this makes it an attractive material in terms of economic recovery. Several other EWPs are derived from hardwoods, the types most often imported from foreign countries into Japan, and thus would not encourage domestic forest production to the same degree as CLT.

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<sup>116</sup> Al Shuler and Craig Adair, “Engineered Wood Products: Production, Trade, Consumption and Outlook” in the *United Nations Economic Commission for Europe/Food and Agriculture Organization for the United Nations Forest Products and Annual Market Review*, (Geneva, Switzerland: United Nations, 1999-2000), 137, <http://www.unece.org/fileadmin/DAM/timber/docs/rev-00/11.pdf>.

<sup>117</sup> Hidehiko Fumoto, “Developments on CLT in Japan,” *Canada Wood Today: The Canada Wood Group Blog*, <http://canadawood.org/blog/developments-on-clt-in-japan/>.

<sup>118</sup> *Annual Report*, 2010, 6.

<sup>119</sup> *Annual Report*, 2013, 3



**Figure 15:** Dormitory in Ōtoyo Town,  
the first CLT structure in Japan.

*Source: Kōchi-ken Ōtoyo-machi, 2015*

While CLT is well-established in Europe, work on the implementation of CLT products and systems have just begun in Japan. The Japanese government and scientific communities agree that CLT is a special material that has a place in recent initiatives that support domestic procurement of timber and harvesting of wood from local, responsibly managed forests. Specific applications for CLT have not yet been determined, but studies are well underway. Although CLT is not yet fully a material permitted by law to be used in Japanese buildings,<sup>120</sup> the Abe regime has indicated that they are ready to subsidize half the cost to construct CLT buildings for the purpose of promoting the expansion of CLT structures, with the added intention of stimulating local economies to manufacture this medium.<sup>121</sup> This signifies that the Abe government is extremely supportive of promoting further research so that CLT can be adapted into the Japanese built environment as soon as possible. Moreover, on November 11, 2014,

<sup>120</sup> Japan Agricultural Standards, Ministry of Agriculture, Forestry, and Fisheries, Government of Japan, “Chokkō shūsei ita no nihon nōrin kikaku,” December 20, 2013, [http://www.maff.go.jp/j/jas/jas\\_kikaku/pdf/kikaku\\_clt.pdf](http://www.maff.go.jp/j/jas/jas_kikaku/pdf/kikaku_clt.pdf). CLT is listed as an acceptable material for structural design as listed in the above link to the Japanese Agricultural Standard 3079, but structural design criteria is still needed for CLT to be officially recognized in the Building Standard Law, enabling the material to be applicable in public building architecture.

<sup>121</sup> “Kokusan sugi kenzaei no fukyū, seifu ga sokushin shinsei chōsenryaku,” *Nikkei Shinbun*, June 24, 2014, [http://www.nikkei.com/article/DGXNASFS2003C\\_T20C14A6PP8000/](http://www.nikkei.com/article/DGXNASFS2003C_T20C14A6PP8000/).

MAFF announced a roadmap with plans for Japan to produce five hundred thousand cubic meters of cross laminated timber annually by fiscal year 2024, further demonstrating government support of CLT.<sup>122</sup>

Although research on the benefits of CLT have not been yet completed in Japan, strong evidence in support of CLT has emerged within the country.<sup>123</sup> In March 2014, the Building Research Institute (BRI) published an article in the Japan Journal that explains the ways their organization has been studying CLT buildings and how they can engineer CLT to prevent fires from spreading embers and to mitigate other hazards (*See Figure 16*).<sup>124</sup> Annually, the Japan CLT Association holds several events and seminars that attract hundreds of participants from the building and housing, engineering, machinery, academic, and government sectors, including five hundred who attended the most recent forum held in March of 2015. At this forum, the keynote speaker voiced the opinion that CLT is a solution for developing long-lasting wooden building materials, a change from practices borne out of Buddhist doctrine in Japan that advocate replacing wood often as a symbol of renewal.<sup>125</sup> In January 2012, the Japan CLT Association was established with a few business members and, as of April 2015, has surged to two hundred and fifteen corporate members.<sup>126</sup> With scientific, academic, and government support,

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<sup>122</sup> Hayashi no chō, “CLT no fukyū ni muketa rōdomappu,” 2014, <http://www.rinya.maff.go.jp/j/press/mokusan/pdf/141111-01.pdf>.

<sup>123</sup> CLT has been popular throughout Europe for 20 years. It is backed with extensive research and a documented track record of outstanding building performance.

<sup>124</sup> Ichiro Hagiwara, Koji Kagiya, and Junichi Suzuki, “Fire Safety Measures Enabling Construction of Large Wooden Buildings (Part I),” *The Japan Journal* 10, no. 12 (2014): 30-33, <http://www.kenken.go.jp/english/contents/topics/japan-journal/pdf/jj2014mar.pdf>.

<sup>125</sup> Nihon CLT Kyōkai, “Dai san ka, CLT fōramu o kaisaishimashita,” *Saishin jōhō*, March 27, 2015, <http://clta.jp/news/2055/>.

<sup>126</sup> Nihon CLT Kyōkai, “Ippan shadan hōjin Nihon CLT Kyōkai seikaiin meibo,” April 24, 2015, <http://clta.jp/wp-content/uploads/2015/04/a41f1fae5f58a61b80c544fa49e2ee452.pdf>.



recognition of CLT as a medium to be used in public building construction alongside wood and other EWPs is positioned to grow.



**Figure 16:** Fire testing of CLT performed by the Department of Fire Engineering, Building Research Institute of Japan.

*Source: Ichiro Hagiwara, et al., 2014*

A larger challenge is attaining widespread acceptance of CLT and wood products in general as suitable materials for tall building applications by stakeholders involved in the stages of a structure's production, including those who fund its completion and the users who will be occupying the spaces. Perhaps the best solution to this barrier is to dispel common misconceptions by clarifying topics and promoting knowledge of CLT. In a survey conducted in America of those involved in the architecture, engineering, construction, and developer industries, only fifty-eight percent knew of the capabilities and attributes of CLT in public structures, but ninety-two percent answered that CLT would be a viable alternative to the post-tensioned concrete typically used once educated on the merits of CLT.<sup>127</sup> Moreover, in a European questionnaire that asked owners and developers of CLT buildings if they would be interested in pursuing new projects that use similar technology or systems, nearly eighty-eight

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<sup>127</sup> Schmidt and Griffin, 4-6.

percent responded “yes” citing low carbon footprint, building energy performance, light weight structure, and durability among the most influential reasons.<sup>128</sup> It can be hypothesized that if similar CLT education initiatives and surveys took place in Japan, the results would be comparable. National and regional education programs can begin once thorough analyses of the performance of CLT are conducted in Japan.

A series of shake-table tests that were performed in Japan, known as the SOFIE Project (2007) and NEESWood Project (2009), are two of the most significant studies done that have affected the perception of wood and CLT for architects, designers, scientists, government, stakeholders, and consumers who have been skeptical about the ability for these materials to be earthquake resistant. The SOFIE Project was a research undertaking lead by Italy’s National Research Council of Italy Trees and Timber Institute to test the performance and potential of CLT in multi-story projects. Working with the National Research Institute of Earth Science and Disaster (*Kokuritsu Kenkyūkai Hatsuhōjin Bōsai Kagaku Gijūtsuken*) in Miki, Japan, a group of Italian and Japanese scientists measured fire-resistance and earthquake durability against simulated, extremely strong seismic forces. The major achievement of the project was that a seven-story building constructed entirely of CLT withstood massive earthquake damage and

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<sup>128</sup> Forestry Innovation Investment and the Binational Softwood Lumber Council, *Summary Report: Survey of International Tall Wood Buildings*, May 2014, 3-6, <http://www.rethinkwood.com/sites/default/files/wood-resource-pdf/Survey-of-International-Tall-Wood-Buildings.pdf>.

tremors, resulting in researchers concluding that it is a suitable material for use in earthquake-prone areas as shown in Figure 17.<sup>129</sup>



**Figure 17:** The seven-story CLT building that withstood earthquake forces during SOFIE Project testing.

*Source: Romano Magrone, 2012*

The NEESWood Project builds off of the testing that was done during the SOPHIE Project. Working with the same Research Institute of Earth Science and Disaster Prevention in Japan, this experiment was headed by Colorado State University, supported with funding from America's National Science Foundation's Civil, Mechanical and Manufacturing Innovation Division. A six-story Capstone wood-framed condominium was assembled along with an

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<sup>129</sup> "Progetto SOFIE," L'Istituto per la Valorizzazione del Legno e delle Specie Arboree del Consiglio Nazionale delle Ricerche, last modified January 31, 2013, <http://www.ivalsa.cnr.it/sofie.html> and Ario Ceccotti, Carmen Sandhaas, Minoru Okabe, Motoi Yasumura, Chikahiro Minowa, and Naohito Kawai, "SOFIE Project - 3D Shaking Table Test on a Seven-storey Full-scale Cross-laminated Timber Building," *Earthquake Engineering & Structural Dynamics* 42, no. 13 (2013): 2003-2021.

equivalent benchmark structure composed of concrete with steel framing. While the concrete structure did provide “life safety” against tremors that were recreated to be like the Northridge earthquake in California (1994) but with 1.16 times the intensity, it was ruled that repairing the substantial damage that did occur would be costly.<sup>130</sup> The wooden Capstone structure, shown in Figure 18, satisfied all performance targets, experiencing only non-structural damage at the Maximum Credible Earthquake level of shaking. Of the damage that occurred, replacing wood is less costly than the concrete and steel used for the benchmark structure.<sup>131</sup> Recently, Canada’s FPInnovations took these discoveries even further by using the NEESWood Project as a model to conduct similar research replacing the wood materials used with CLT to support similar findings in the SOPHIE Project, concluding that “CLT as a structural system is a viable option for mid-rise buildings in moderate and high seismic regions.”<sup>132</sup> Based on studies done by Japanese organizations like the Building Institute in Japan and the Japan CLT Association<sup>133</sup> and knowledge from the Italian, American, and Canadian experiments, support appears strong in the government, architectural, design, and engineering sectors.

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<sup>130</sup> John W. van de Lindt, “Contributions to and from Industry within the NEESWood Project,” (presentation, NEES 6<sup>th</sup> Annual Meeting, Portland, OR, June 2008), slides 7-14,

<http://www.nsf.gov/news/newsmedia/neeswood/slides/sld014.jsp>.

<sup>131</sup> “Standing Strong: 2009 NEESWood Capstone Test,” National Science Foundation, last modified June 5, 2009,

<http://www.nsf.gov/news/newsmedia/neeswood/> and

Marjan Popovski, Shilling Pei, John W. Van de Lindt, Erol Karacabeyli, “Force Modification Factors for CLT Structures for NBCC” (presentation, RILEM Symposium, Stuttgart, Germany, January 2013), accessed from [http://www.researchgate.net/profile/Marjan\\_Popovski/publication/274959406\\_Force\\_Modification\\_Factors\\_for\\_CLT\\_Structures\\_for\\_NBCC/links/552d54b30cf29b22c9c4f1f9.pdf](http://www.researchgate.net/profile/Marjan_Popovski/publication/274959406_Force_Modification_Factors_for_CLT_Structures_for_NBCC/links/552d54b30cf29b22c9c4f1f9.pdf).

<sup>132</sup> Popovski, 10.

<sup>133</sup> Three of the most recent CLT studies:

1) Nakajima Kōichirō, “CLT no fukyū no tame no sōgōteki dēta no shūshū/ chikuseki oyobi kentō kekka seika hōkokusho,” Nihon CLT Kyōkai, March 2014, <http://clta.jp/wp-content/uploads/2015/04/2361bfa5ce1fb49702fc6ba4b25e30fc.pdf>.

2) Nakajima Kōichirō, “Sugi CLT no zairyō tokusei, yukakamaemen no sendanseinō,” Nihon CLT Kyōkai, March 2013, <http://clta.jp/wp-content/uploads/2013/01/e7b5704203d0fb1ca3731cdf0a26c46e.pdf>.

3) Nakajima Kōichirō, “Sugi CLT yuka no onkyō shiken,” Nihon CLT Kyōkai, March 2013, <http://clta.jp/wp-content/uploads/2013/01/405a3cf1984cecf49eb0c1b02693ae0e.pdf>.



**Figure 18:** Wooden Capstone structure from the NEESWood Project.

*Source: John van de Lindt, 2009*

Contemporary Japanese metropolises have already begun to incorporate wood and other wood-derived products in public buildings, but in the future, CLT is situated to be the next piece in this long narrative of material culture in Japanese urban history. While the Abe administration, other government officials, BRI scientists, and members of the Japanese CLT Association may be in support of swift lawmaking decisions, more research is needed that supports the findings in past programs like the SOPHIE Project. Once these have been completed and CLT officially becomes an acceptable material to use in buildings, it is an EWP that can reinvigorate Japanese forestry production markets if the proper regulations are set in place by governments, businesses, and policymakers.

## CONCLUSION

In a compelling and unexpected way, the 1964 Tokyo Olympic Games, the 1998 Nagano Olympic Games, and the upcoming 2020 Tokyo Olympic Games tell distinct stories that reflect crossroads regarding the future of material use in Japanese urban architecture. In 1964, upon winning the bid for the Olympics, the Tokyo Metropolitan Government went to great lengths to transform Tokyo into “the most dynamic city on the face of the Earth”<sup>134</sup> by using the most modern materials of the time: concrete and steel. Architect Kenzō Tange built the Yoyogi National Gymnasium with reinforced concrete pillars for support with draping, distinct curves that form the exterior and interior of the structure. The materials have come to symbolize much of the contemporary landscape of Japanese cities, as concrete and steel were the materials that provided the most structural stability and resiliency at the time.

In a bold step away from the exclusive use of “modern” steel and concrete that came to characterize much of post-war Japan, the world’s largest wood suspension roof crafted out of local *karamatsu* encircles the M-WAVE ice skating rink used for the 1998 Nagano Olympics. This building “lend[s] a bit of a mountain-lodge hominess”<sup>135</sup> as the design is intended to resemble the mountain ranges of Nagano. The wood used in this structure is limited to the roof and is not applied on a large scale throughout the design, as is the case with some of the more recent contemporary wood structures in Japan. There are also four features that contribute to sustainable design: a device that uses heat from the freezer to heat the inside of the building, energy-saving windows that provide sunlight and air flow, CFC-free cooling systems, and multi-

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<sup>134</sup> “For Gold, Silver & Bronze,” *TIME*, October 16, 1964.

<sup>135</sup> Paul Newberry, “Skating Venue Creates Its Own Special Memories,” *The Associated Press*, February 13, 1998, <http://www.washingtonpost.com/wp-srv/sports/longterm/olympics1998/nagano/articles/mwave.htm>.

functional arrangement capabilities.<sup>136</sup> These elements demonstrate a gradual shift to sustainable designs, although assessment systems like CASBEE did not yet exist in the late 1990s.

For the 2020 Olympics, a non-profit organization known as Team Timberize (*Tēmu Tīnbaraizu*) developed a project that called for the application of wooden venues to end the “era of concrete” in Japan. In their Timberize Tokyo 2020 exhibit, wooden models that were designed by over one hundred architects and students were showcased to prompt discussion on the possibility of including multiple wooden structures in the city, including ones planned for the Olympic Games.<sup>137</sup> Other ideas their team has contributed to urban planning discourse include the Omotesando 7 Project for Tokyo as well as projects for cities in Shizuoka and Kumamoto Prefectures<sup>138</sup> that challenge the status quo of conventional architectural design while exploring new applications of wooden products.

Design concepts like those developed by Team Timberize indicate a shift in how architects and planners are visualizing the future of Japanese cities. To make these structures, CLT and other wood-derived products will have a place in the discourse of Japanese architecture, particularly in the disciplines of urban and environmental history. It is too early to know to what extent these mediums will be used by architects, engineers, designers, and construction professionals to alter urban landscapes, but evidence suggests that CLT will make a major impression on Japanese material culture. In addition to CLT and other EWPs being the most environmentally friendly choice because wood is a renewable resource, newly engineered design elements positively influence their performance with few barriers. As wooden products,

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<sup>136</sup> “About M-WAVE,” M-WAVE Corporation, [http://www.nagano-mwave.co.jp/m\\_wave/language/en.php](http://www.nagano-mwave.co.jp/m_wave/language/en.php).

<sup>137</sup> Kenji Tsuji, “NPO calls for wooden venues at 2020 Tokyo Olympics,” *The Asahi Shimbun*, September 12, 2014, [http://ajw.asahi.com/article/behind\\_news/social\\_affairs/AJ201409120045](http://ajw.asahi.com/article/behind_news/social_affairs/AJ201409120045).

<sup>138</sup> “Omotesando 7 Project,” TeamTimberize, <http://www.timberize.com/design.html>.

CLT and other EWPs also have inherent energy efficient properties like airflow regulation. Additionally, new CLT and other wooden products are now engineered to withstand fire and other natural forces. Indeed, resilience and sustainable design agendas can merge into *one* architectural paradigm now that these materials exist.

Furthermore, CLT, as a product derived primarily from softwood, can be a solution to revitalizing Japanese forests and wood production markets as long as carefully planned wood harvesting and thinning practices continue to take place. It also is a material choice that can improve conditions like overpopulation in cities when applied to tall buildings. While many, like Prime Minister Abe, have expressed their support for CLT initiatives, more research must be done to ensure that the material adheres to strict Japanese building codes and that it is as ecological as it is purported to be, although this is well-documented and established in other global contexts. Once the studies are complete, construction-related legislation should be passed in Japan to further foster growth in this area of development due to the limitation of government subsidies.<sup>139</sup> Like most other cultural phenomena, the shifting applications and physical properties of wood and wood products in architecture mirror greater political, economic, and social changes that have taken place in Japanese history. As Japan is on the verge of a “wood renaissance,” CLT is positioned to be the option most aligned with contemporary resiliency and sustainability initiatives in Japan’s search for the greenest and strongest building materials.

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<sup>139</sup> “Ringyō saisei he kokusan zai wo ikasu gijyūtsu kaihatsu o,” *Nikkei Shinbun*, May 4, 2014, <http://www.nikkei.com/article/DGXDZO70775520U4A500C1PE8000/>.



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## **Education**

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**Loyola University Chicago**, Chicago, Illinois

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*Bachelor of Arts in History and International Studies, minors in Asian Studies and Anthropology*

**Sophia University**, Tokyo, Japan

*April – July 2009*

## **Honors and Awards**

East Asian Studies Center Travel Grant, Phi Alpha Theta History Honors Society Member,  
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## **Relevant Professional Experience**

**Consulate-General of Japan** Chicago, Illinois

*March 2013 - present*

*Technology and Information Coordinator*

*Freelance Translator and Web Development Professional*

**Indiana University**, Bloomington, Indiana

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*Associate Instructor of Japanese 101*

**Carroll High School**, Fort Wayne, Indiana

*September 2010 - June 2011*

*Associate Instructor of Japanese levels 1, 2, 3 and 4*

**Japan America Society** Chicago, Illinois

*August – December 2009*

*Intern*

## **Skills**

*Languages:* Native English speaker and professional proficiency in Japanese. Learning Spanish.

*Public Relations:* Demonstrated ability to determine goals, establish objectives, and define communication tactics based on social media trends and review analytics; compose and design e-newsletters primarily on Japanese-American political, economic, and cultural affairs;

*Public Relations (cont'd):* plan events and collaborate with other organizations to bring ideas to full fruition; draft speeches and remarks for myself and others; deliver presentations to schools, institutions, and community centers; research newspapers and other sources to monitor government affairs; design websites, print media, press releases, and promotional documents.

*Technology:* HTML, CSS, JavaScript, WordPress, Adobe, EndNote, Microsoft Office.

### **Recent Publications, Presentations, and other Contributions**

Reconciling Sustainable and Resilient Design in Cities: Cross Laminated Timber and the Future of Japanese Wooden Buildings

*Master Thesis July 2015*

Various presentations while employed at the Consulate, including but not limited to: Japanese business etiquette, tea ceremony, education, *koto* instrument performance, and emcee duties.

*March 2013 - present*

113 Project

*Subtitle transcriber and translator December 2014- May 2015*

Kobe Resurrected: Popular Protest in Kobe after the Great Hanshin Earthquake of 1995

*Presentation at the East-West Center's International Graduate Student Conference*

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Kobe University's Digital Archive: Analyzing a New Dimension in Social Memory

*Term paper December 2012*

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日本の節電も反核運動 (Japanese Power Conservation and Anti-Nuclear Energy Movements)

*Research project and presentation at the Inter-University Center in Yokohama August 2012*

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*Research project and presentation at the Inter-University Center in Yokohama August 2012*

Meiji Misfortunes: The Stories of Oine and Hanzo

*Term paper May 2012*

The Perpetuation of Burakumin Issues Today – Shimazaki Toson's The Broken Commandment

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